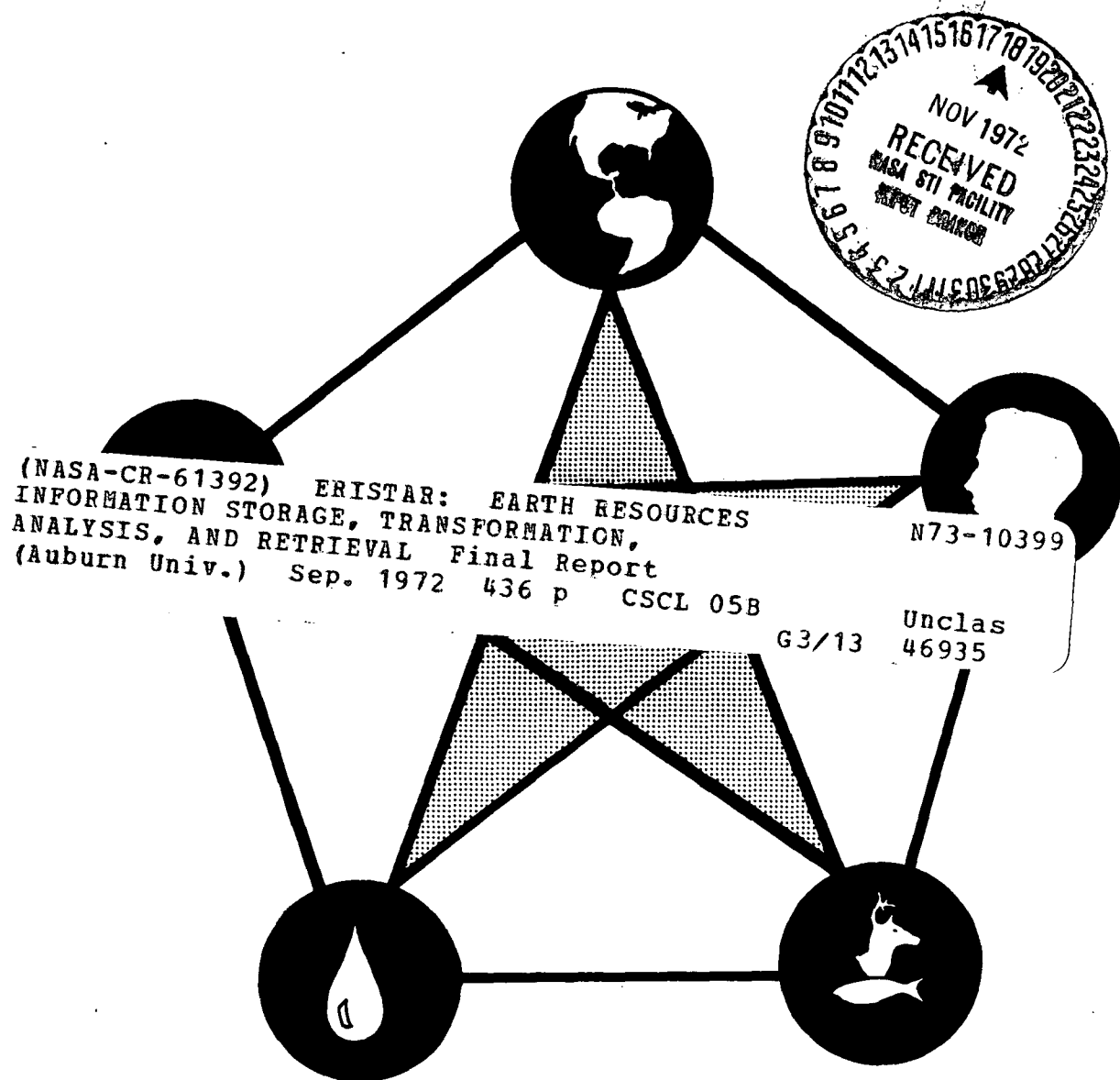


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NASA CR-61392

ERISTAR



SCHOOL OF ENGINEERING
AUBURN UNIVERSITY
AUBURN ALABAMA 36830

FINAL REPORT
NASA GRANT NGT-01-003-044

NASA/ASEE SYSTEMS
DESIGN SUMMER
FACULTY PROGRAM

NOTE

The information in this report represents the views of the participants and does not necessarily reflect the views or policy of NASA, or those of any other government agency or private corporation.

COVER EXPLANATION

The five symbols connected by a pentagon and encompassing a star on the cover represent the unity of environmental resources as considered by the ERISTAR designers. The symbols starting with the earth at the top and proceeding counter clockwise represent : the atmosphere, hydrosphere, biosphere and man himself.

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16. ABSTRACT <p>The National Aeronautics and Space Administration (NASA) and the American Society for Engineering Education (ASEE) have sponsored faculty fellowship programs in systems engineering design for the past several years. During the summer of 1972 four such programs were conducted by NASA, with Auburn University cooperating with Marshall Space Flight Center (MSFC).</p> <p>The subject for the Auburn-MSFC design group was "ERISTAR," an acronym for Earth Resources Information Storage, Transformation, Analysis and Retrieval, which represents an earth resources information management network of state information centers administered by the respective states and linked to federally administered regional centers and a national center.</p> <p>This report outlines the considerations one must make to serve the users and the considerations that must be given to processing data from a variety of sources. The combination of these elements into a national network is discussed and an implementation plan is proposed for a prototype state information center. The compatibility of the proposed plan with the Department of Interior plan, RALI, is indicated.</p>			
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The success of any program depends on the library services available and the willingness of librarians to serve the user. The NASA Regional Information Center is run by a dedicated group as is the Redstone Scientific Information Center. These two centers have, over the years and especially this summer, gone to great lengths to support the NASA/ASEE programs and we sincerely appreciate the efforts of all the professionals in the center, who support us, especially Ms. Charlotte Dabbs.

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ERISTAR

Earth Resources Information Storage, Transformation, Analysis, and Retrieval

by

AUBURN UNIVERSITY ENGINEERING SYSTEMS DESIGN

SUMMER FACULTY FELLOWS

FINAL REPORT

CR-61392

Prepared Under

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION


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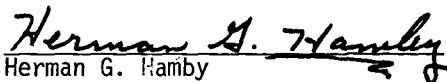
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The Report

ERISTAR, an acronym for Earth Resources Information Storage, Transformation, Analysis and Retrieval, represents an earth resources information management network of state information centers administered by the respective states linked to federally administered regional centers and a national center. The definition of earth resources as used herein is broad and indicates natural resources plus man-made resources such as dams, irrigation systems, etc. An information management system is a formal organized approach to handling, coordinating enhancing and augmenting data and information supply and demand among multiple organizations and individuals.

The report outlines the considerations one must make to serve the users (planners at the state and local level) of the proposed information system and the considerations that must be given to processing data from a variety of sources - satellites, ground based data banks or monitoring systems. The combination of these elements - sources, processing, users and management - into a national network is discussed and an implementation plan is proposed for a prototype state information center.

The report proposes that the existing federal, state and private information systems be included in the national network. Furthermore, the need for existing federal facilities and agencies to support research, development and implementation for the ERISTAR system is stressed.

The compatibility of the proposed plan with the Department of Interior plan - RALI - is indicated. The two proposed plans appear to result in a similar system except that ERISTAR begins at the state level and grows toward the federal level. A marriage of the two plans with other studies aimed at the same objective with the same criteria and constraints is encouraged by the ERISTAR designers.

The Summer Training Exercise

The writers digress from the normal form of an abstract to include a summary of the training exercise that generated this report. This summary is as prepared by one of the fellows for the final oral presentation and is felt to be representative of the group's feelings.

"You have heard the final presentation of ERISTAR by the Auburn-Marshall Space Flight Center, Engineering Systems Design Summer Faculty Fellows. True, this may be the last time the Staff and all Faculty Fellows

collectively review this summer's work. But--with the launching of a new package today, it is only the beginning for ERISTAR. We can be justifiably proud of ERISTAR.

"What made ERISTAR happen? The spadework by the Staff and supporting organizations for the summer program was not loudly broadcast. However, the arrangements for the program were well planned, coordinated and complete.

"Flash back to June 5, 1972, when fifteen (15) naive academicians and a participant from NASA met in the lobby of Building 4200. At the time it was natural to wonder how so much variant expertise could be tuned for today's concert. Each participant, recognized for his accomplishments in a particular discipline and arriving from many different states, would influence all others in many ways. The personal associations, not only with the Staff and participants but all supporting personal contacts, have made a lasting impression.

"Systems engineering, or the systems approach, was not a novelty to several of the participants. But applying the systems approach to a subject as broad as earth resources information had mystifying connotations.

"It was interesting to experience the motivation that is developed through group dynamics. Creating a feeling of desire for accomplishment is very contagious.

"In some respects the systems approach may be compared to presenting an orchestral concert. The wood wind, brass, string or percussion sections of an orchestra may represent the task force groups of the summer program. The formation of task groups would appear to diverge interest and efforts allowing individuals and groups to play different parts. Each section composing its own music or each task force group preparing disparant copy for a report does not sound very coordinated or conducive to a synchronous crescendo.

"Intense action was the schedule for the day. Practice sessions or group meetings were held. The rooms were not soundproof. A cacophony of loudly tooting disciplines was heard. The tempo was furious and fortissimo was the level of activity. Sometimes we heard a solo, sometimes a duet; frequently a quartet as the members of the task group became better acquainted and attuned to the problem, and we were presented with opportunities to listen to many authorities and operate the latest equipment, effecting innovations in action.

"There seemed to be no end to the syncopation of the typewriter and discordant tunes began to be heard. Then we experienced the maestro's touch as Director Reggie, supported by his Staff, began to arrange the tone of the theme. "Don't prejudge! What are the constraints and criteria? Is that an objective or a requirement?" Occasionally showing

how to perform, but mostly just humming his tune was all the motivation we needed. The facilities and environs challenged the participants to exceed expectations.

"It was exciting to be involved in a contemporary problem. The summer program enhanced our skill in systematic problem solving. We were in a unique position to experience group dynamics in action and broaden our knowledge in systems approach.

"You have heard the results of this summer's experience presented as ERISTAR. We are in concert but not in stereophonic sound. ERISTAR will be watched by all the participants awaiting realization when ERISTAR is an ongoing system receiving applause for an encore.

"Speaking for the participants, we extend our sincere appreciation to all who made this summer program possible."

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PREFACE

PROGRAM DESCRIPTION

The National Aeronautics and Space Administration (NASA) and the American Society for Engineering Education (ASEE) have sponsored faculty fellowship programs in Systems Engineering Design for the past several years. NASA, having used and developed this systems approach and realizing its general usefulness, has shared its experience with the educational community through Summer Faculty Fellowship Engineering System Design Programs conducted jointly by a NASA center and a cooperating university. Four such programs were conducted during the summer of 1972.

- o Marshall Space Flight Center - Auburn University.
- o Langley Research Center - Old Dominion College.
- o Manned Spacecraft Center - University of Houston.
- o Ames Research Center - Stanford University.

The George C. Marshall Space Flight Center (MSFC), Auburn University, and the University of Alabama conducted two systems design programs in 1967 and 1969, and MSFC and Auburn University conducted the 1970 and 1971 programs.

Each program uses a real-world training exercise to give the 15 to 20 faculty participants an opportunity to test the approach and live through and evaluate the group dynamics of the effort. The training exercise has an added advantage in that each center and NASA, through sharing the support of the programs, benefit from interaction with the faculty. The result of the training represents an unbiased study and opinion on a topic of interest to NASA. Each participant then carries this experience to his home institution where either he may develop class projects that use a similar approach, or he, with others, may select a project to involve faculty and students to solve a real problem using this approach. An outstanding example of spin-off is the program conducted during the summer of 1971 by graduates of the MSFC-Auburn-Alabama 1969 and 1970 programs. Dr. Ordean Anderson and Prof. Mel Forthun of North Dakota State University, Dr. Denny Mathiason of Moorhead College and Dr. Duane Dahlberg of Concordia College conducted a systems approach, faculty summer program applied toward development of the Red River Basin of the North. This program was patterned after their experiences in 1969 and 1970 at MSFC. This project, funded by the Office of Water Resources, shows a concrete result of involvement with NASA and demonstrates spin-off of a technique from NASA applied to the civilian economy. Dr. Anderson

and the others have stated that without the 1969 and 1970 experiences, their project would never have been developed.

THE SYSTEMS APPROACH

The systems approach has been adopted as a more general terminology than systems engineering to describe the philosophical approach and view to the solution of complex multidisciplinary problems. The definitions given to the systems approach are as many as the definitions of beauty, which exists in the eye of the beholder. Two encompassing definitions for consideration are: (1) "the solution of a complete problem in its full environment by systematic assembling and matching of parts to solve the whole problem, in the context of the lifetime use of the system or plan, considering all aspects",¹ or (2) an optimal solution or strategy to a complex multidisciplinary problem. Exhibit 1 shows the steps involved in the systems approach procedure and emphasizes the four steps of the approach: (1) translation, (2) analysis, (3) trade-off, and (4) synthesis. These terms are defined as follows:

Translation - determining a common language (or terminology) for the statement of the problem objective and the criteria and constraints that are acceptable to, and understandable by, all participants.

Analysis - determining as many alternative approaches as possible to solve the problem as a whole or to solve portions of the problem.

Trade-Off Study - applying selection criteria and constraints to choose the combination of alternatives to meet the objective.

Synthesis - a combination of the analysis and trade-off phases to achieve a "best" solution to the problem statement that was structured during the translation phase.

Other terms used in the approach are defined as:

Objective - the function of the system or the strategy that must be achieved, performed, or accomplished.

Requirement - a partial need (stated in the most generic form) to satisfy the objective. A requirement may be itself an objective for a subsystem study.

Alternative - one of many ways to satisfy or implement a requirement.

Criterion - a measure of the desired performance of the system or strategy to meet the objective.

Constraint - an upper or lower limit on the system or strategy.

1. Frosch, Robert A.: "A New Look at Systems Engineering." IEEE Spectrum, vol. 6, no. 9, 1969, p. 24.

This report shows the result of the systems approach and also gives some insight into the approach. As is indicated in Exhibit 1, the Logic Flow is from left to right. The selection criteria and constraints (physical, fiscal, timing and policy) used to control the trade-off of alternatives are either imposed by the political, physical and economic environment in which the system must operate or established by the system designer. It should also be understood that this logic process must be repeated in a cyclic manner as a system is developed from the initial concept to the final functioning system or strategy. The four steps - Translation, Analysis, Trade-off and Synthesis - are carried out in each cycle; feed-back exists between cycles as well as between steps within a cycle. Each succeeding cycle gives more detail to the developing strategy or solution. These diagrams do not indicate the necessity for involving many disciplines, nor do they indicate the necessity for attention to the group dynamics involved in progressing to a solution, strategy, or plan, whether it is an embryonic or a final system.

1972 MSFC-AUBURN SYSTEMS APPROACH EXPERIENCE

The development of an Earth Resources Information Management System constituted the suggested work statement for the 1972 MSFC-Auburn Engineering Systems Design Summer Faculty Fellowship Program. The exact task to be accomplished by way of the training exercise for the ASEE-NASA sponsored program was not specified. It was decided by the staff of the program that a problem as large as Earth Resources Information Management should be approached in a systematic way consistent with the program intent and an objective or task should be identified using a systems approach.

The basic systems approach as employed is illustrated in Exhibit 1. As is seen, any problem is viewed as consisting of an objective, requirements to satisfy the objective, and constraints and criteria which are controls that must be considered when trading off approaches to the requirements to arrive at a plan or means of satisfying the objective. The steps of the systems approach used seem obvious until the problem becomes complex and one has difficulty in identifying an objective, requirements, constraints, and criteria.

It is easy to state that applying the systems approach to a complex problem is difficult but it is hard to convey the difficulties once the approach is applied and the well-ordered steps are set out to show what was done. The reader of this document must realize that application of the systems approach to Earth Resources Information Management is not easy but the lucid presentation of the problem as a result of applying the process is worth the effort involved. First, the Earth Resources Information Management problem is multidisciplinary in nature with ill-defined interrelationships of disciplines. The material presented establishes how the MSFC-Auburn faculty fellows attacked a problem area foreign to many in the group. The chronology of events should prove useful to anyone uninitiated to the problem area who thinks of applying

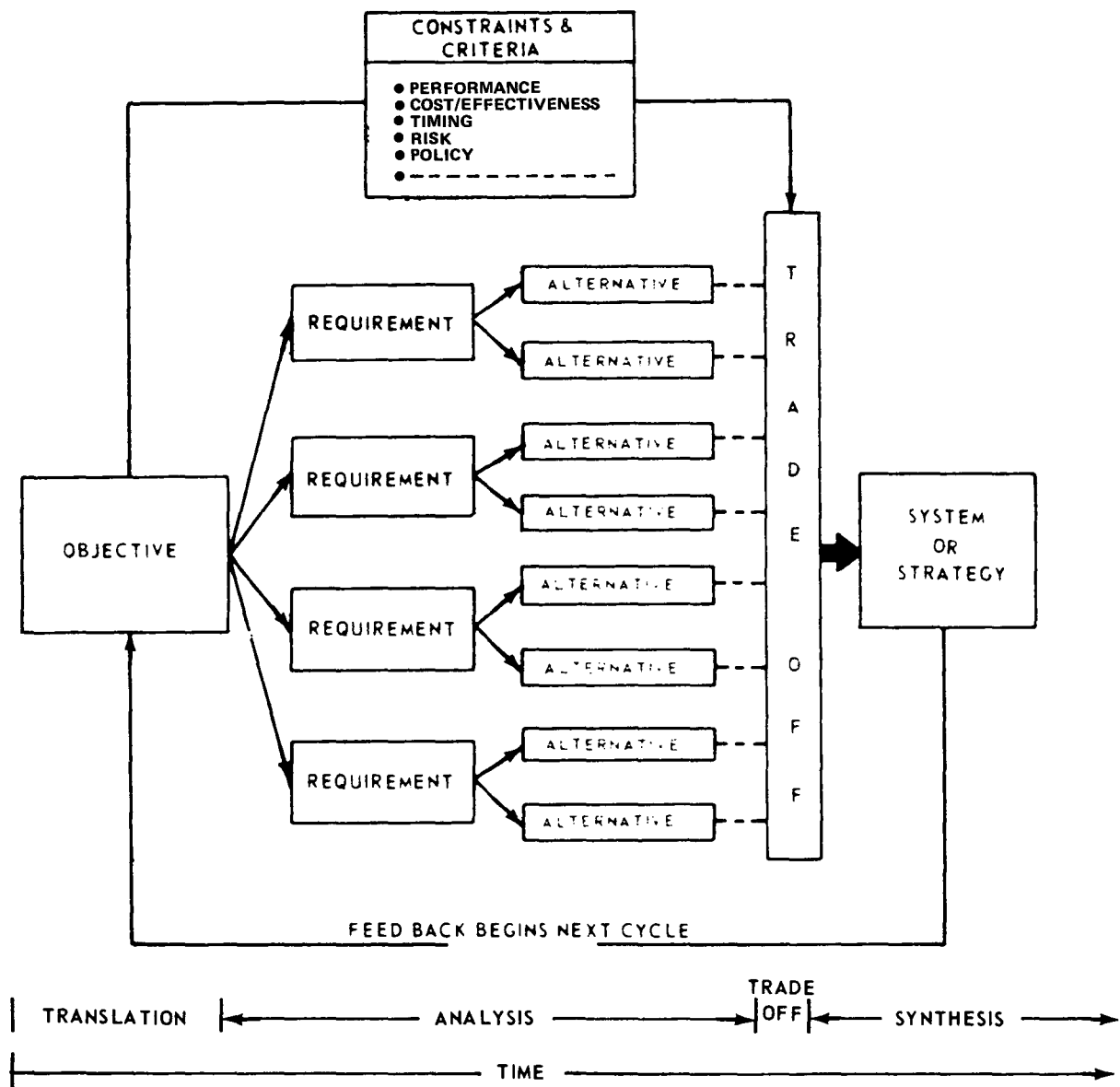


EXHIBIT I: A SYSTEMS APPROACH

the systems approach or systems engineering. The group effort represents about 1.5 man-years of work, considering the first half of the problem as an information-gathering process. The following discussion traces the events of the group and sets the stage for the reader.

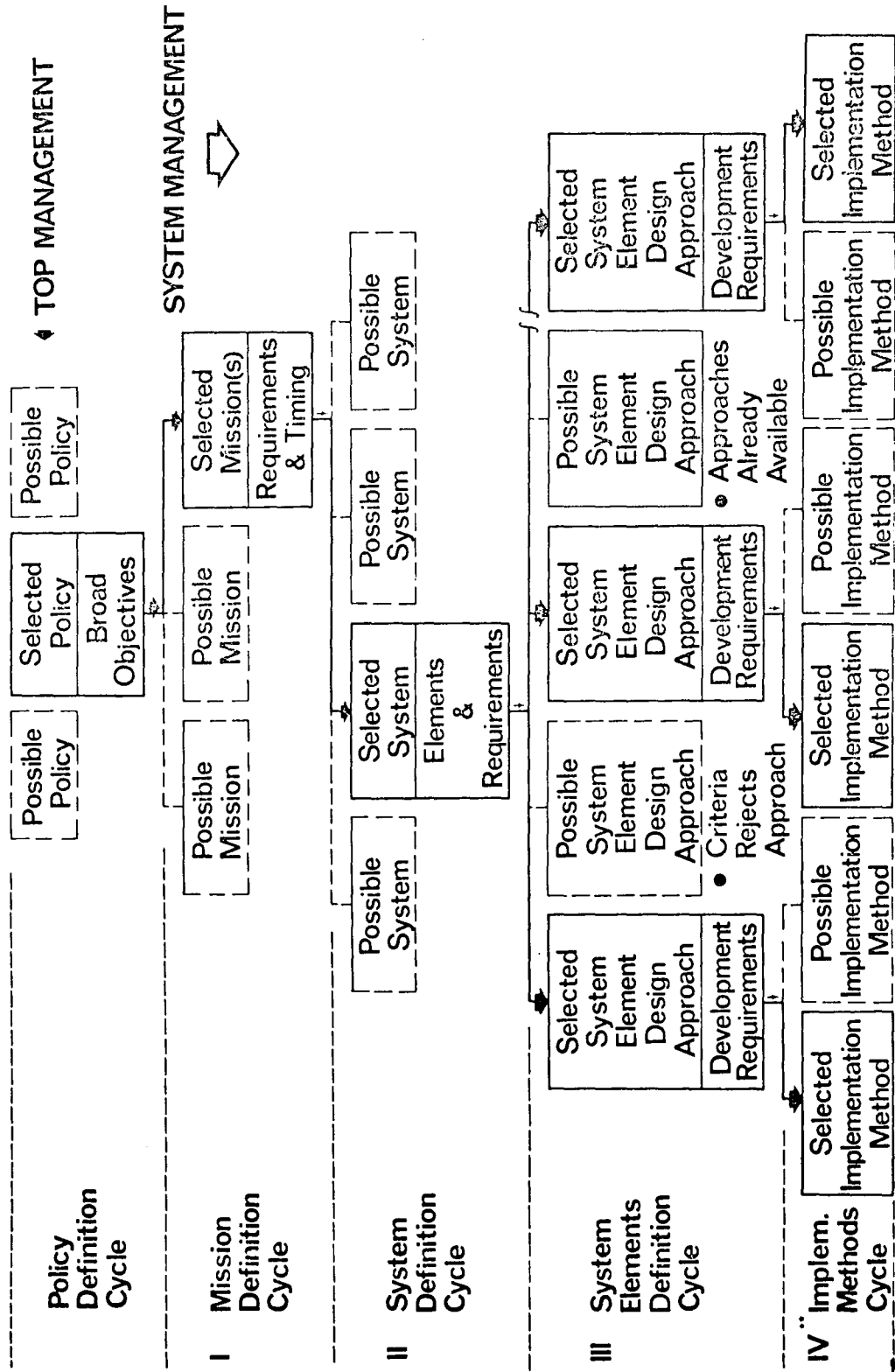
On Friday of the first week at MSFC, the fellows commenced to consider the problem as described in the first paragraph. The following Monday, the fellows decided that before an objective could be well defined, they would need information on Earth Resources and Information Systems. The report of the 1970 MSFC-Auburn Engineering Systems Design team--the UNISTAR (User Network for Information Storage Transfer Acquisition and Retrieval) Report (NASA CR 61333)--provided valuable initial guidance to the 1972 Design team. As a result, the major requirements for an Earth Resources Information Management System were specified as sources of data, processing of data, user services and management of the system. One will see in each of the chapters how each requirement, in turn, becomes a objective for a task group.

The fellows elected task-group leaders and project leaders three times during the course of the program as shown in Appendix E-2. Also, it should be pointed out that the fellows volunteered membership for a particular task group. It is interesting to note the task group organization during the three phases of the program. As is seen, the participants created a management task group during the 2nd phase in addition to an ad hoc prototype committee. Various participants served on one or more task groups or committees simultaneously during the course of the program. Speakers were selected by the staff and participants and summaries of their remarks are in Appendix F-2 to this report.

The reader should view the report keeping in mind the following points:

- The ERISTAR Designers agreed with the policy suggested by the UNISTAR Designers - that there should be a national information management system under the auspices of the Federal Government. The ERISTAR Designers did not conclude that the system should be totally administered by the Federal Government.
- The ERISTAR result represents a continuation of the system study begun by the UNISTAR Designers. UNISTAR resulted in a Policy. ERISTAR carries this study through the Mission Definition Cycle to the System Definition Cycle. Some aspects of ERISTAR forge into the System Elements Cycle of Exhibit 2. The ERISTAR concept should go through a recycling at the mission definition level after the prototype plan is carried out on the state level. Thus, although recommendations have been made for significant progress, it is realized that field evaluation of the concept is essential to true systems planning.

EXHIBIT 2: SEQUENCE OF CYCLES IN THE SYSTEMS APPROACH



** Implementation Methods Include Advanced Development Plans, or End Item Req'ts

The ERISTAR Designers were sponsored by NASA but the Designers have acted as an independent group mindful that they did not, because of time, have a complete picture of all agencies and groups working in earth resources. The result of the study uses a NASA Center as an example and cites NASA achievements in remote sensing of earth resources data and its application but does not intend nor feel that the results of the study are limited to NASA involvement in the concept.

ACKNOWLEDGEMENTS

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The successful completion of project ERISTAR would have been impossible without the enthusiastic cooperation of the offices and personnel of the Marshall Space Flight Center and the many government agencies, private industries and individuals who participated in the program. It is impossible to give recognition to each individual; however, we have attempted to list certain speakers and others who have been most instrumental in the success of the project. These contributors are listed in Appendix F.

We wish to express our thanks to Dr. E. F. M. Rees, Director of MSFC; Dr. W. R. Lucas, Deputy Director; Mr. R. W. Cook, Deputy Director; Col. E. Mohlere, Assistant to the Director; Dr. H. K. Wiedner, Director of Science and Engineering; Dr. Ernest Stuhlinger, Associate Director for Science; Mr. Marion Kent, University Affairs Office and Dr. George Bucher, Deputy Associate Director for Science. Mr. Herman Hamby, our Co-director, deserves our particular appreciation as does Dr. George McDonough, Director of the Environmental Applications Office (EA), Mr. Jim Daniels of EA, Mr. Ted Paludan and all the staff of EA. The Environmental Applications Office served as the host for the program and we appreciate the attitude, spirit and support provided by our host. Mrs. Pat Nicaise in EA was gracious to us and made us feel we were part of the "EA family".

The tours and arrangements made through the Protocol and Transportation Branches have been very valuable to our program. Thanks are due to many, but Mr. E. S. Schorsten and Cmdr. W. V. Martin are two individuals who made "it" happen.

The enthusiastic support of Mr. J. F. Dowdy, Chief of the Training Branch, and Mr. C. M. Hightower has proven invaluable over the course of the program and we say "thank you" for helping us in so many ways. Ms. J. M. Miller and Ms. Jimmie Dew of Program Development deserve a word of appreciation for their continued assistance during the program.

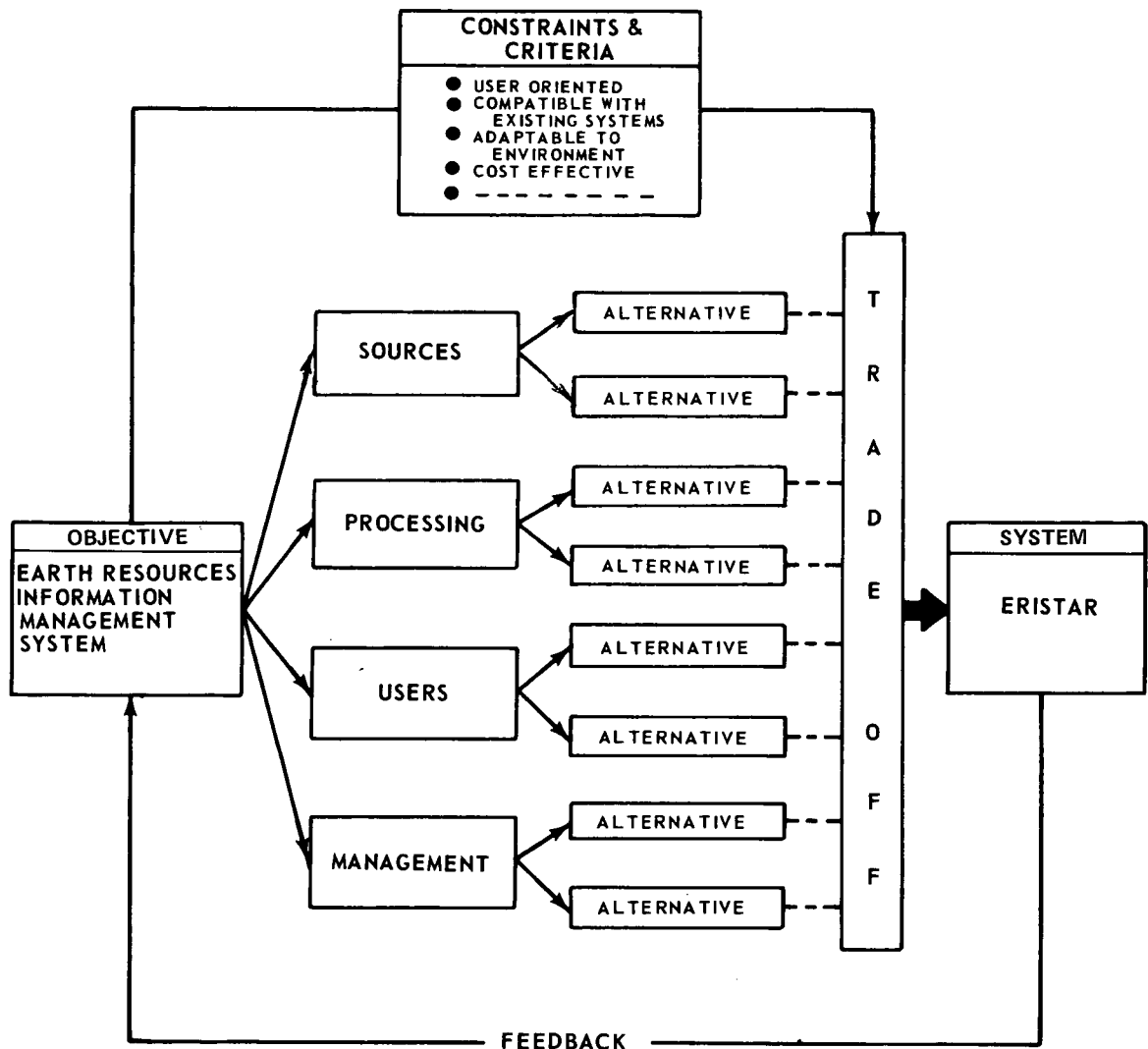
The illustrators who worked under pressure and met all deadlines while maintaining their composure are due our thanks. We appreciate the work of Garland V. Trammell, Charles D. Edwards, Harry R. Melson and Roosevelt S. Dixon of Hayes International, Inc.

The continued support and funding of these summer programs rest with two individuals, Dr. Frank Hansing and Mr. Charles Carter of the Office of University Affairs at NASA Headquarters. The educational

community is indebted to these individuals and their colleagues who have had the foresight to promote these efforts and who continue to support this contribution by NASA to society.

The assistance of the MSFC administrative assistants and secretaries, as well as our own, is appreciated. Ms. Bonnie Holmes, Ms. Molly Payne, Ms. Pat Nicaise of MSFC and Ms. Sue Dempsey, Ms. Barbara Babes, Mr. Mikki Seagraves and Mr. Preston Buchanon, summer employees in EA at MSFC and Ms. Wanda Rushing, Ms. Anece McIlwain, Ms. Kathy James, Ms. Jane Bass and Ms. Linda Bryan comprise this list of excellent supporters of our effort.

1. INTRODUCTION



SUGGESTIONS FOR READING THIS REPORT

Each succeeding chapter will have as its first page a replica of the systems approach diagram which began this introductory chapter. The portion of the diagram elaborated upon in that chapter will be highlighted in the flow chart. Chapters 2, 3, 4 and 5 will cover the subsystems; Sources, Processing, Users, and Management, respectively. Within each of those chapters additional systems approach flow charts will be used to structure the discussions. This should aid the reader in following the development of the ERISTAR system concept.

Each of the following four chapters (2 through 5) reflects the work of distinct task groups. The intent in each is to present the flow of ideas that ultimately yielded suggestions for an earth resources information management system. These flows were not necessarily all smooth. Accordingly the reader may wish to skim through chapters 2 through 5 and proceed quickly to chapter 6 and the discussion of the ERISTAR system. Chapter 7 presents a recommended program for implementing the ERISTAR concept, beginning at the state level. Chapter 8 contains important recommendations and conclusions. Appendices A through D are supportive of Chapters 2 through 5 respectively. The remaining appendices support the report in general.

1.1 THE CONCERN FOR EARTH RESOURCES

The central tenet of economics is that resources are limited in supply while the demand for those resources is unlimited. Thomas Malthus looked at one resource, food supply, and reasoned its linear growth would not match the exponential growth of population. Since Malthus' time there have been significant improvements in the world supply of food. Man, however, has begun to realize that corresponding improvements cannot be made in the supply of other resources, e.g., clean air. Resources are increasingly recognized as not being inexhaustible or indefinitely renewable. More importantly, the interdependence among resources is recognized. This is crystalized in the expression "Spaceship Earth", the pictures of the planet by the Apollo astronauts dramatized this idea. This new consciousness tells us we must carefully manage our resources. Information about resources must be available to make that management work. Hence, the objective of this design study -- an earth resources information management system.

1.1.1 What Are Earth Resources?

The increased sensitivity to the cruciality of resources has spawned a number of terms, e.g., human resources, marine resources, recreation resources. These are in addition to the more familiar natural resources, mineral resources, and the like. No one, however, appears to have set down a formal definition of earth resources, perhaps assuming the interpretation of the term was obvious. Such an assumption will not be made here. The following definition is thus offered:

Earth resources are those parts of the natural and man-made physical environment which are presently or potentially useful to man.

The inclusion of man-made elements in the definition is made to distinguish earth resources from natural resources. For example, an irrigation system is not a natural resource but is an earth resource. Note that natural resources are regarded in the above definition as an important subset of earth resources. Note also that this is a very "generous" definition, i.e., a wide variety of items are included. The broad scope thus implied by the term "earth resources" has obvious ramifications for information systems concerning earth resources.

To illustrate the scope or breadth of earth resources examine Exhibit 1-2. Four major categories are depicted: air, water, land, and life. In the scientific disciplines man analyzes these resources and associated phenomena. Via the technical and management "disciplines" man applies these resources to his needs. Both perspectives (scientific, technical plus managerial) are concerned with the abuse, man-made and natural, and the use of earth resources.

An interesting categorization of resources is made by William A. Fisher of the U. S. Department of the Interior:

- Real resources, e.g., minerals
- Quasi-resources, e.g., scenic beauty
- Anti-resources, e.g., floods.

1.2 THE EARTH RESOURCES INFORMATION PROBLEM

Just as there is a high degree of awareness of resource problems and issues there is a similar level of awareness concerning the "information explosion." This explosion has resulted from twin forces: the increased generation of knowledge and the increased dissemination of knowledge (made possible by the rapid strides in computation and in communication).

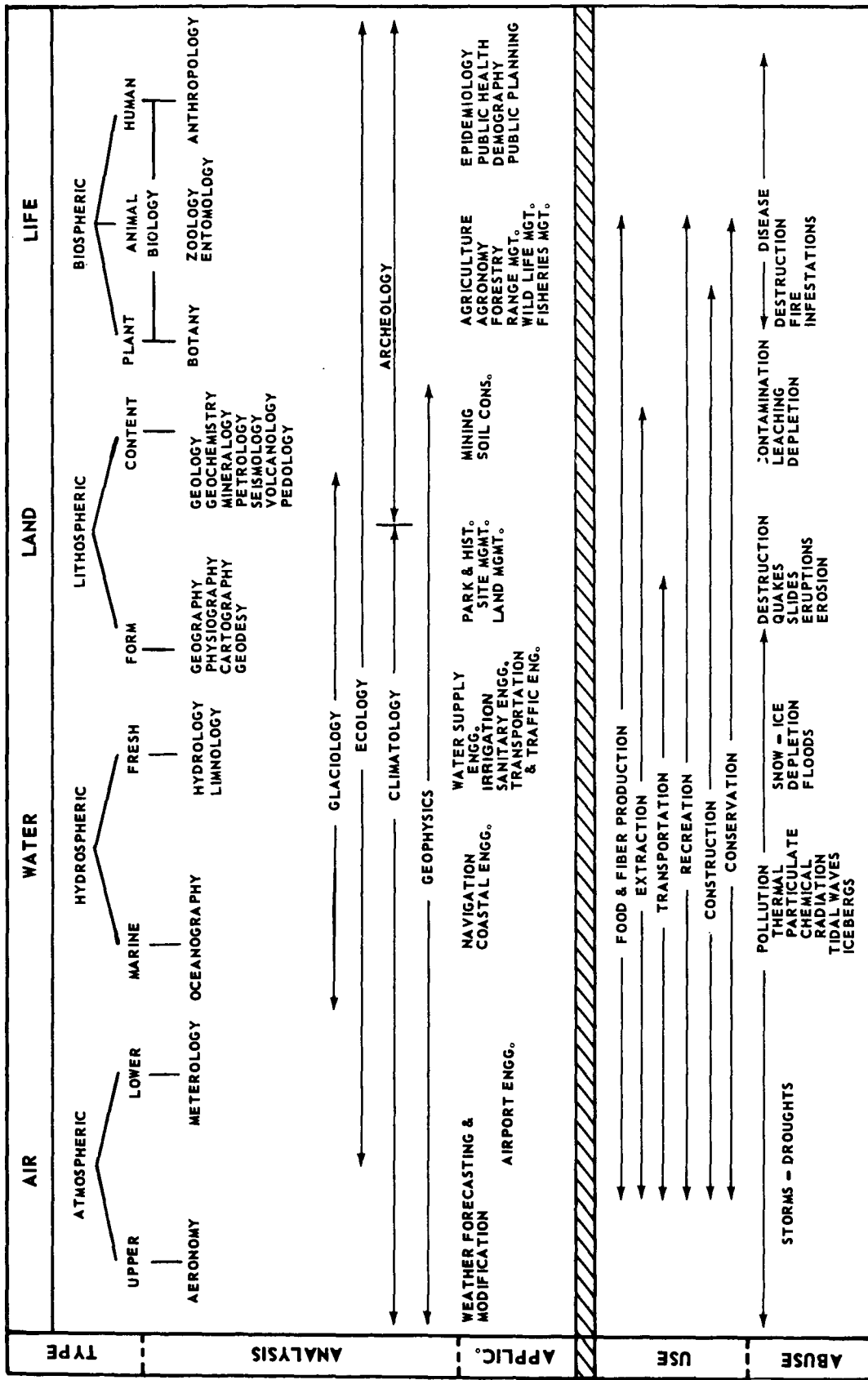


EXHIBIT 1-2: EARTH RESOURCES CATEGORIES AND INVOLVEMENT PATTERNS

1.2.1 A Paradox

The flood of information inundating society has, of course, produced problems. There is a perverse, paradoxical character to these problems. On the one hand scientific researchers are confronted with a vast array of literature to be searched in beginning an investigation. On the other hand decision makers involved with resource interactions find they sorely lack sufficient pertinent information. Witness the painful experiences of public utility firms and governmental agencies when trying to assemble environmental impact statements for contemplated construction projects.

Exhibit 1-3 portrays the many routes which information travels in the domain of science. Because of the vital role such information plays in the development of nations the United Nations Educational, Scientific and Cultural Organization (UNESCO) undertook a study jointly with the International Council of Scientific Unions (ICSU) on the feasibility of a world science information system [1].* They concluded that not only was a world-wide system necessary but it was also feasible. The UNESCO-ICSU Central Committee called their study and the resultant solution UNISIST. As a system UNISIST would be "a world-wide network of scientific information services working in voluntary association." The Central Committee made 22 recommendations for fostering increased cooperation in sharing and transferring information.

The above example illustrates how the world community has attempted to cope with information over-abundance in the area of science. An illustration of how the world community has addressed the problem of a dearth of organized information for environmental decisions is found in the United Nations Conference on the Human Environment held in Stockholm during June 1972. The Conference recommended the establishment of an international Information Referral Service for sources of environmental information [2]. In addition to cataloguing "all relevant governmental and international sources" of technological and scientific information pertaining to environmental matters the Referral Service would also catalog:

- data
- social and economic information
- legislative, administrative and policy information
- public information .

"Each entry to the catalog would contain the name, address, cable and telephone number of the information source, together with details of the controlling body, function, subject coverage, services and availability. These attributes would be sufficiently categorized, indexed and annotated to ensure efficient retrieval." Governments and UN agencies would be the users of the service.

*A number within brackets, [] relates to the list of references at the end of this chapter. This convention will be used throughout the report. A bibliography appears after Chapter 8.

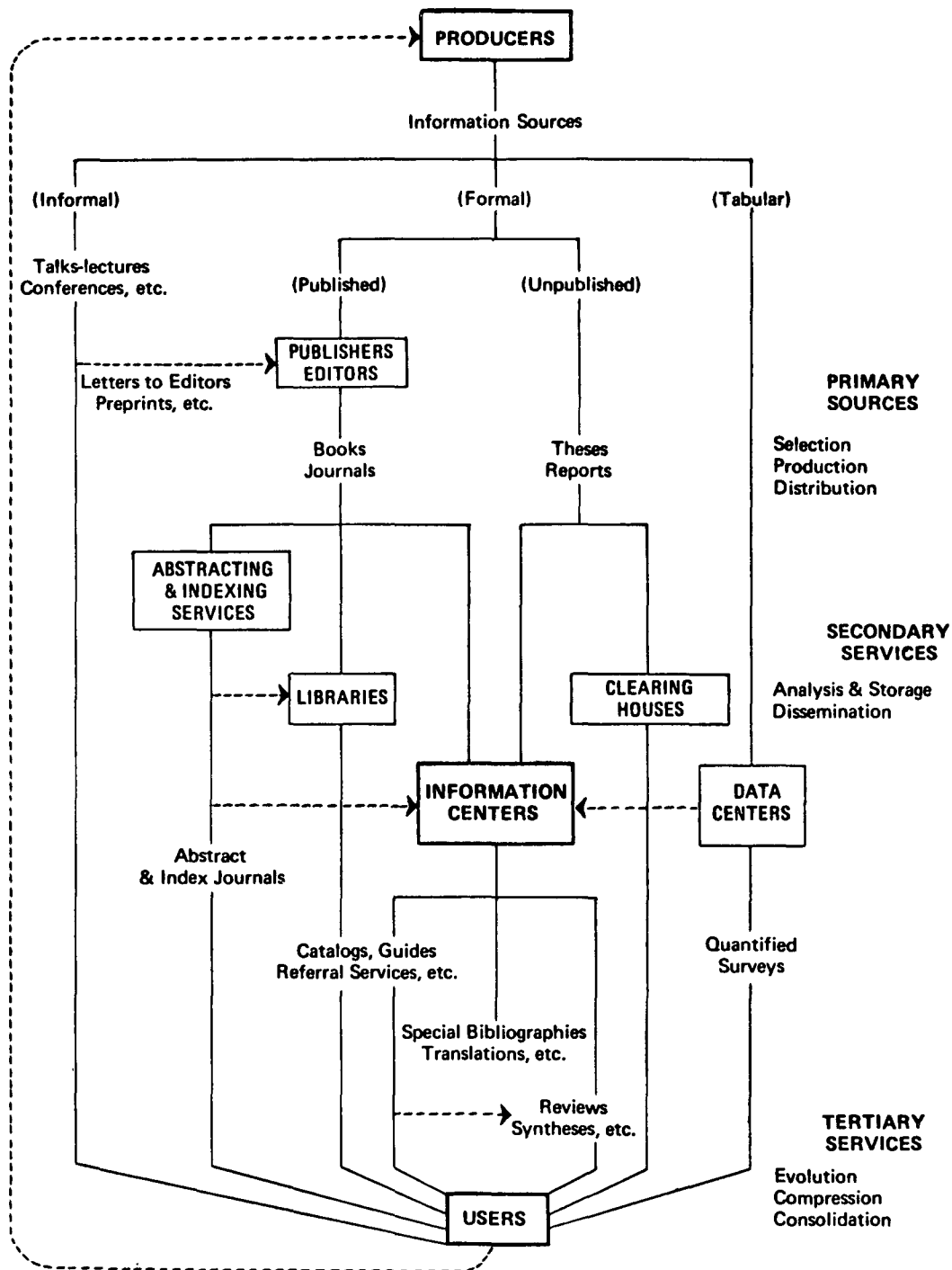


EXHIBIT I-3: THE FLOW OF SCIENTIFIC-TECHNICAL INFORMATION [1]

The preceding two examples--UNISIST and the Information Referral Service--show man's attempts to deal with the prosperity/poverty paradox concerning information quantity and availability. Obviously this same situation exists with regard to earth resources information.

1.2.2 Marshalling Earth Resources Information

Two major categories of data and information must be marshaled or brought together in tackling earth resource problems and issues. These categories are the existing and the emerging. The former includes an incredible variety of material, e.g., from a collection of drilling core samples in a university researcher's laboratory to a computerized federal data bank containing water quality indicators for bodies of water in the United States to a consulting engineer's report on underground thermal energy sources. Thus existing earth resource information sources are disparate--they cover many different aspects and appear in many diverse forms. In addition, these sources are widely dispersed. Each state, for example, has compilations of data and assemblages of information concerning its resources. More importantly there is considerable disorganization of these data and information sources--even within states! Instances have been reported where one state's geological unit did not even know that the forestry unit had conducted aerial photographic surveys. In light of the undesirable characteristics, mentioned above, that existing sources of earth resources data and information seem to possess, it is understandable that the application of that data and information to earth resource problems and issues is disjointed. Correspondingly, the present state of earth resource management is, on the whole, poor.

1.2.2.1 Remote Sensing

A major class of emerging data and information on earth resources is that derived from remote sensing. This term applies to remotely made measurements of a phenomenon of interest. That is, the sensor or measurement device is not in direct contact with the item under study. Remote sensing as a concept is not new--aerial photography has been around for some thirty years [3]. What is new and dramatic is the wide variety of sensors now in use and under development plus the placing of sensors at considerably remote distances, such as at orbital altitudes. Remote sensing exploits the fact that most materials selectively absorb, transmit, reflect, and emit radiation from various portions of the electro-magnetic spectrum. The state-of-the-art in electronic and optical instrumentation is such that radiated and reflected energy can be recorded at considerable distances, e.g., on space platforms such as satellites. Sensing devices used include: cameras (photographic and TV), radiometers, spectrometers, and radars. When such instruments are placed in mobile platforms (aircraft, spacecraft) the following advantages accrue:

- remote areas on the earth can be surveyed
- wide-area or synoptic coverage is possible
- the same instrument can be used to make measurements at all places of interest [4] .

A prime disadvantage of remote sensing is that man does not yet know enough about the "spectral signatures" of various natural and man-made phenomena. Secondly, vast quantities of data are generated in connection with the measurements thereby creating a significant data handling problem. Considerable research is needed to deal with both these shortcomings.

The weather satellite series constitutes a major space-borne remote sensing program, a program now in its operational phase. An outgrowth of this series are the Earth Resource Technology Satellites (ERTS), the first of which achieved orbit on July 23, 1972. The prime aims of the ERTS project are:

- to perfect and develop sensors
- to make inroads into the spectral signature problem
- to develop ways to handle the enormous quantities of data generated by the sensors
- to learn how measurements from space-borne platforms can be combined with aircraft platform measurements and on-site data (ground-truth) in dealing with selected earth resource problems.

Thus ERTS is an experimental satellite. More remote sensing experiments are planned for a follow-on satellite (ERTS-B) and NASA space station projects: SKYLAB, SPACE SHUTTLE.

The ERTS project received its initial impetus from the Department of the Interior's Earth Resources Observation Satellite (EROS) concept [5]. EROS now stands for Earth Resources Observation Systems. Major contributors to the development of ERTS also came from the Departments of Commerce and Agriculture, the Corps of Engineers, the United States Navy. NASA coordinated the development effort. The approximately 300 experimenters involved in the program are undertaking investigation in many areas, such as:

- | | |
|---------------|---|
| ● Agriculture | ● Meteorology |
| ● Forestry | ● Oceanography |
| ● Geology | ● Environmental Quality/Ecology |
| ● Hydrology | ● Geography, Cartography,
Demography . |

While the cost-benefits of earth resources survey efforts are still receiving study, one analysis put the annual economic benefits to the nation at \$59 billion over and above the cost of the technology involved [6]. In light of such figures the strong interest in remote sensing technology and earth resource satellites is understandable. Those

involved in the EROS and ERTS programs are very enthusiastic about the contributions that remote sensing (especially as undertaken from satellites and aircraft) might make to resource management. An important side-benefit, if not the important side-benefit, of the EROS/ERTS programs has been the call for emphasis on information systems for effective management of earth resources. This report is a direct answer to that call.

1.2.2.2 The Need for Information Management

Part A of Exhibit 1-4 summarizes the present conditions with regard to the data and information situation for earth resources. The problems and issues are multi-dimensional and growing. The existing and emerging bodies of possibly pertinent data and information are diverse and very large. A way must be found to harness these "flooding rivers" of data and information. What is needed is an information management-system (Exhibit 1-4, Part B).

1.3 INFORMATION MANAGEMENT SYSTEMS

The advent of the computer has introduced a host of new terms and "buzz words ." Information system is one of these. But what is of concern in this series of paragraphs is something perhaps more grand in scope--an information management system, or IMS for short.

1.3.1 What is an IMS?

An IMS is a formal, organized approach to handling, coordinating, enhancing, and augmenting data and information supply and demand among multiple organizations. The distinction concerning multiple organizations is important. "Information system" and "management information system" (MIS) relate to a single organization.

Information management system, as a term and as a concept, has not yet gained wide-spread use in the field of information science and data processing. One information expert [19] attests to the low currency of IMS. In his view the key characteristic of an IMS is its synoptic perspective on information transfer needs in an area. In the computer programming field, information management system is sometimes used to label a package of related processing programs.

Seeds for the broad usage of IMS were planted by the SATCOM Report [20]. The Committee on Scientific and Technical Communication of the National Academy of Engineering made an extensive, three year study of the information explosion. The Committee proposed an organization for a scientific and technical information network to cope with the problem.

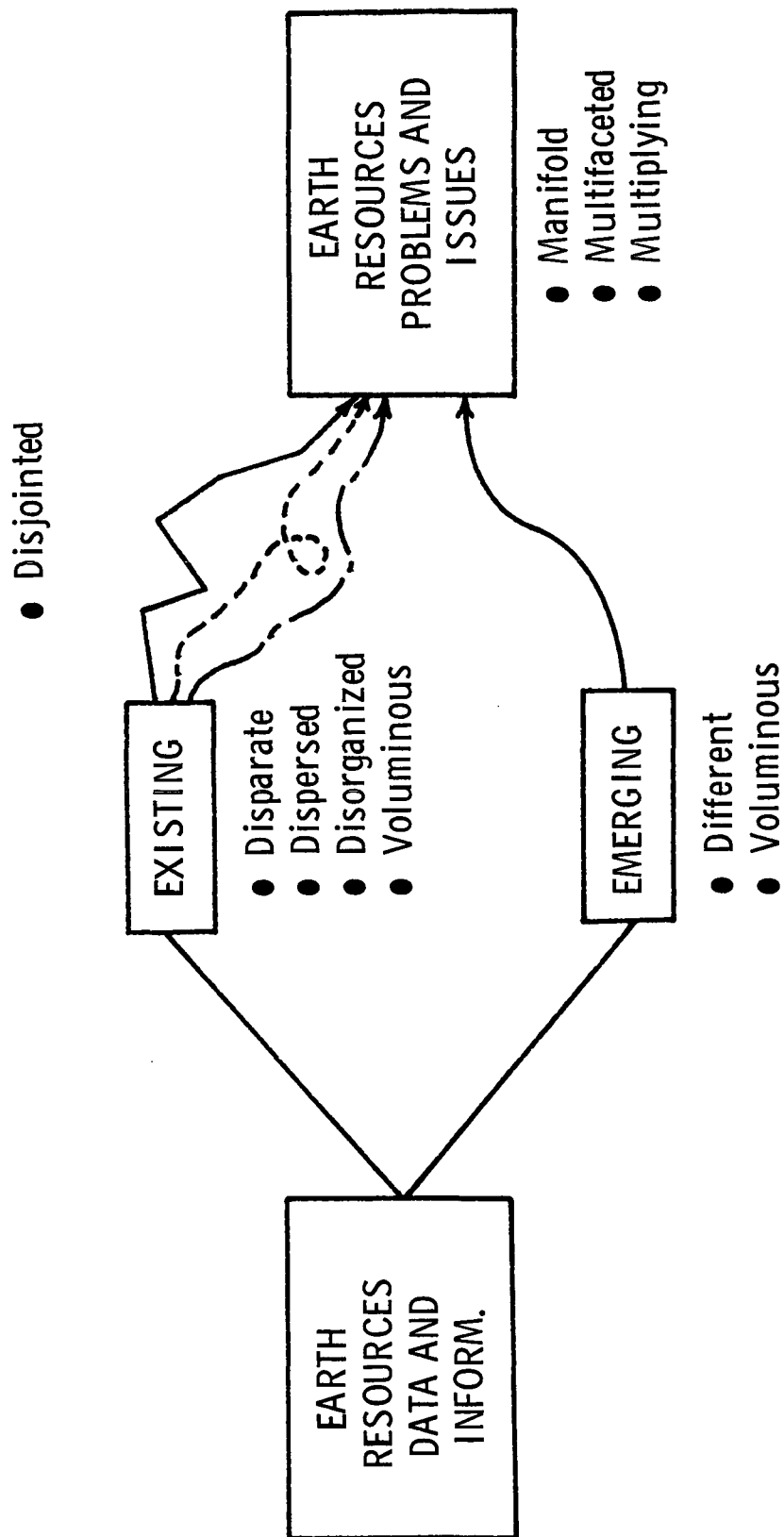


EXHIBIT I-4: THE DATA AND INFORMATION SITUATION FOR EARTH RESOURCES
PART A: PRESENT CONDITIONS

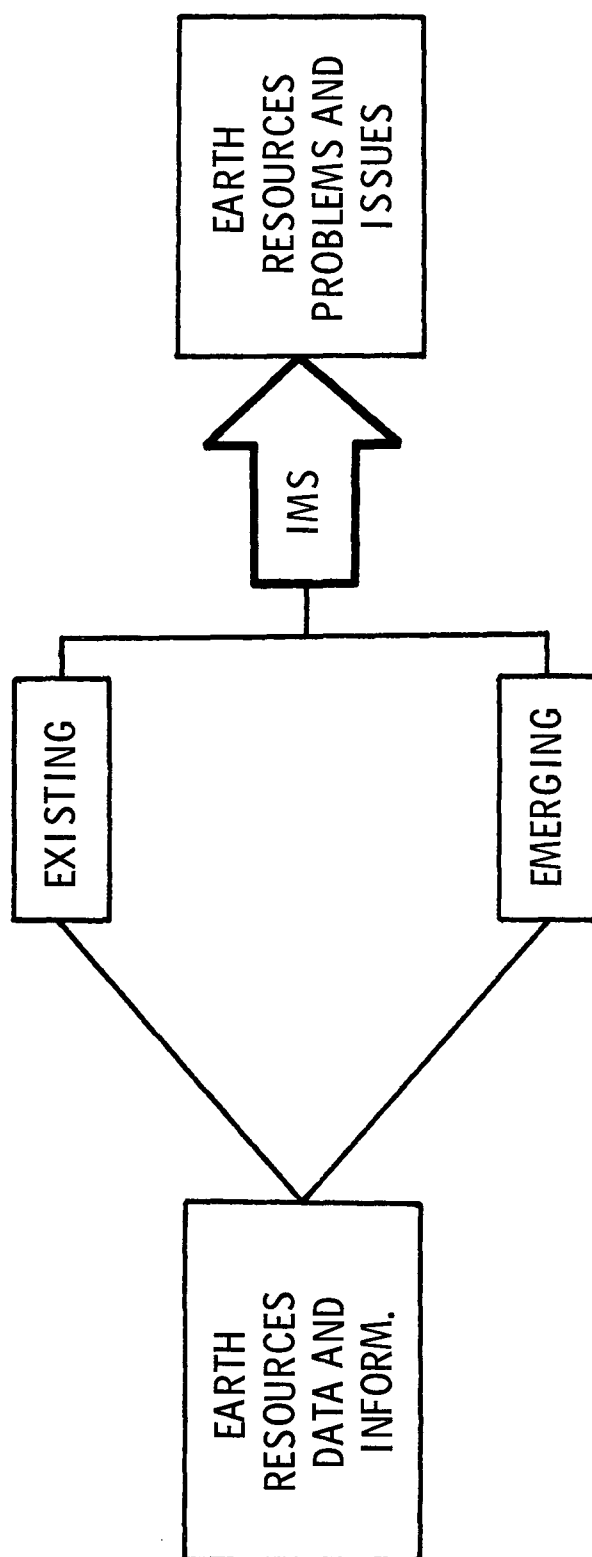


EXHIBIT I-4: THE DATA AND INFORMATION SITUATION FOR EARTH RESOURCES
PART B: WITH AN INFORMATION MANAGEMENT SYSTEM (IMS)

A major study concerning the IMS concept was made by the 1970 Auburn Design Team. Called the UNISTAR Report [7], the study received widespread attention. The IMS described in UNISTAR was heavily user-oriented and "aggressive" in its information dissemination efforts. The latter were carried out by a current awareness center (CAC). The important task of "repackaging" existing and emerging data and information for a specified subject area resided in an information analysis center or IAC. Now an accepted term in the information science field, IAC has been detailed and applied by the Committee on Scientific and Technical Information (COSATI), an interagency body now under the National Science Foundation [8,9]. An information analysis center is defined as:

a formally structured organizational unit specifically (but not necessarily exclusively) established for the purpose of acquiring, selecting, storing, retrieving, evaluating, analyzing, and synthesizing a body of information and/or data in a clearly defined specialized field or pertaining to a specific mission with the intent of compiling, digesting, repackaging, or otherwise organizing and presenting pertinent information and/or data in a form most authoritative, timely, and useful to a society of peers and management [9].

In the UNISTAR Report an information management system was an IAC acting in concert with a CAC to serve a network of users.

1.3.2 Related Concepts

As the reader may have noted earlier information management system sounds like an unintended twist on management information system (MIS). Thus it seems desirable to define the latter.

An MIS aims to serve the managerial personnel of an organization (public or private) with timely, decision-oriented information concerning the organization's operation and performance. A computer is usually employed in an MIS but this is not always a necessary feature. Again note that an MIS is oriented to one organization while an IMS serves many. Note also that for effective operation an IMS requires an MIS; and as IMS complexity grows so does the importance of the MIS.

Another important term is that of data base management. By this one, means the controlled maintenance and utilization of stored data (usually in a computer) for various reporting and/or analytical purposes. Generalized data base management computer programs exist and organized attempts are underway to achieve greater standardization in this important area of data processing [10].

1.4 PREVIOUS STUDIES RELATING TO DATA AND INFORMATION SYSTEMS FOR EARTH RESOURCES

One of the first major studies of information systems for earth resources was that made in 1967-68 by the National Research Council's Division of Engineering for NASA. Included among the report's recommendations was the establishment of a national System for Earth Resources Information (SERI). The SERI scheme would be a "complete informational program for:

- o Inventory and productivity evaluation of the world's food, fiber and other natural resources;
- o Assessment of environmental conditions and of man-environment interactions" [11].

The flow diagram depicting SERI is presented in Exhibit 1-5. Note that despite the claim of being "a complete information program" SERI does not tap the large reservoirs of existing earth resource data and information. SERI is oriented around remotely sensed data and especially satellite-based remote sensing. This bias toward remotely sensed data and information also characterizes the Earth Resources Survey Program (ERSP) as conceived by a 1969 NASA/ASEE Systems Design Program at the Langley Research Center [12].

In the evolution of the Federal Government's Earth Resources Survey Program [13], considerable attention was (and is) being devoted to the handling of the experimental data obtained from airborne and space-borne platforms. The Interagency Ad Hoc Study on the ERSP (now known as the Interagency Coordinating Committee for the ERSP) envisioned the data sources and interested users to be structured as shown in Exhibit 1-6 [11]. Input data from the sensor platforms is corrected and then converted to varying degrees in the NASA centers in Greenbelt, Maryland, and Houston, Texas. The block labelled "Agency Facilities" is used to denote existing aerial photography efforts by such agencies as the Departments of Agriculture and the Interior. Individual and organizational users not directly involved with the experimental program would be able to obtain materials from designated earth resources data centers. This would include the newly-created Earth Resources Observation Systems (EROS) Data Center of the Department of the Interior at Sioux Falls, South Dakota, and a center operated by The Department of Commerce at Suitland, Maryland. The Ad Hoc Interagency Group anticipated that the large amount of imagery and other data formats generated by the ERSP would require a cataloging and retrieval system. NASA's Lewis Research Center has such a system for aerospace safety data--NASIS: NASA Aerospace Safety Information System. NASIS is currently being evaluated for handling ERSP output.

As techniques for remote sensing and spectral signature analysis improve (these two areas are key ERSP experimental efforts), ERSP

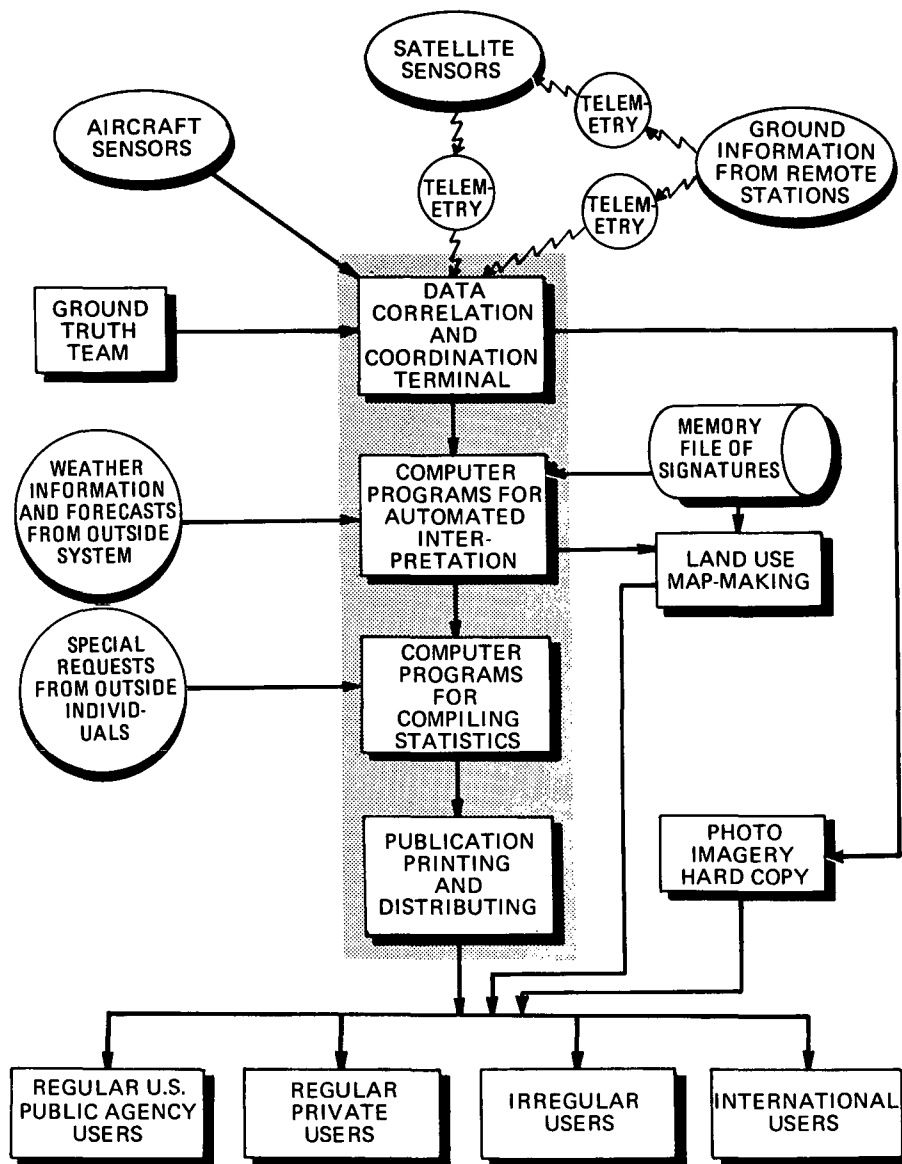


EXHIBIT I-5: SERI: SYSTEM FOR EARTH RESOURCES INFORMATION
AS PROPOSED TO NASA BY THE NATIONAL RESEARCH
COUNCIL [II]

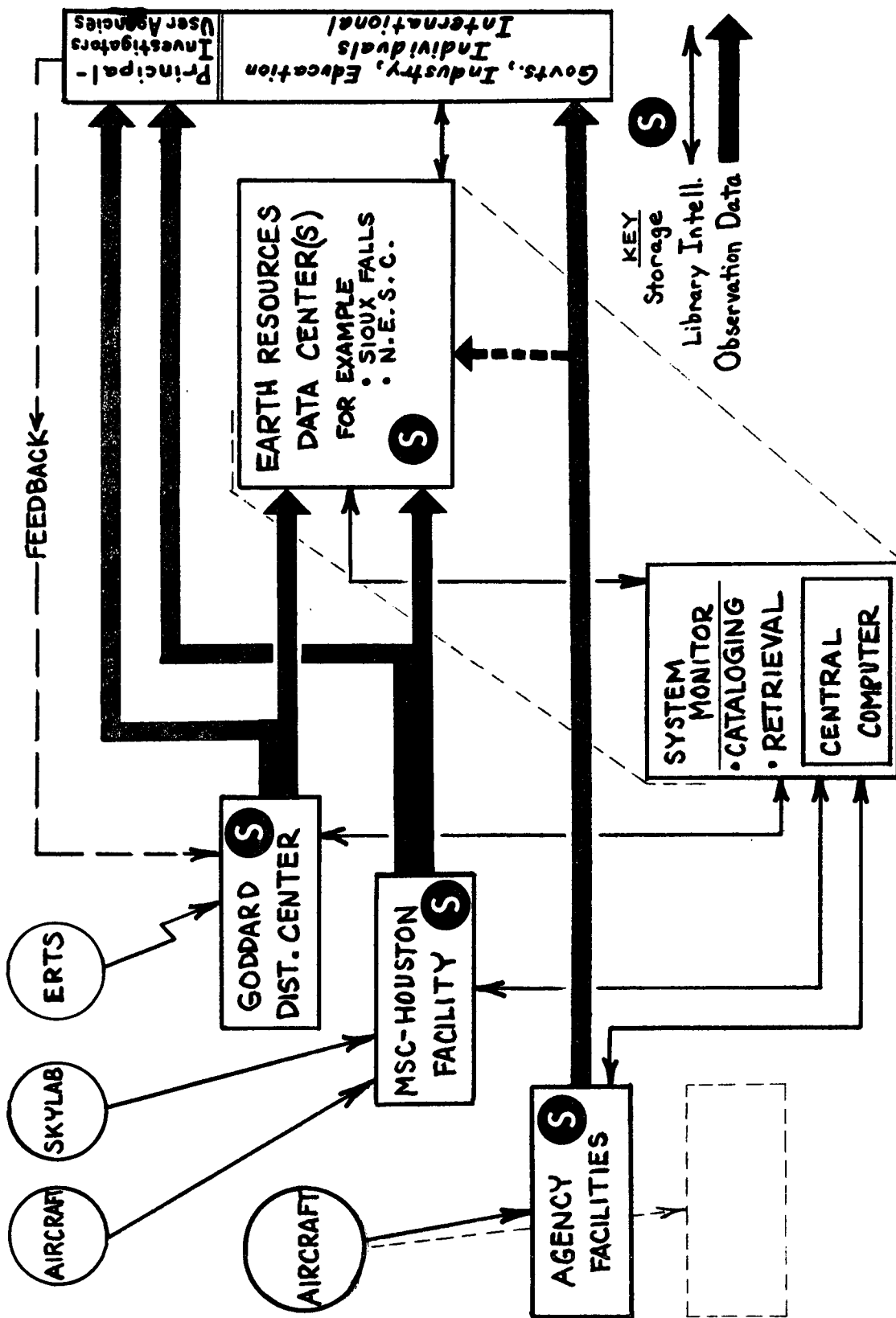


EXHIBIT I-6: ERSP DATA HANDLING SYSTEM -- EXPERIMENTAL PHASE [13]

transforms to an early operational phase, shown in Exhibit 1-7 [11]. Note here that in addition to increased input from new satellites other observational data will flow in. More data centers may be added to the network. In this setting the system monitor takes on increased importance and could be said to take on the form of an earth resources information management system. But it is perhaps puzzling to see in the diagram that a data coordination block is drawn outside the system monitor. One could anticipate that as the total program became more operational in character as the total program performed more of the data coordination. More importantly, note that the overall system remains oriented towards space and airborne sensing platforms. Little indication is given that existing earth resources data and information subsystems are to be included. This bias for space-based data generation can be accounted for by the very severe data rate and volume requirements of the ERSP. As was indicated earlier, an important experimental goal of ERTS and related projects was to make inroads into the data handling problem. To give the reader some feel for the magnitude of this problem consider the following: ERTS sensors are capable of generating the informational unit equivalent of a set of Encyclopedia Britannica every few minutes.

While recognizing the extreme importance of the ERSP data handling problem the authors of this report wish to regard the ERSP as but one component of an information management system for earth resources. As this is a significant departure from previous studies the reader is urged to make careful note.

1.5 AN IMPORTANT STUDY IN PROGRESS -- RALI

RALI stands for Resource and Land Information, an information management program for land use and natural resources under intensive study by the Department of the Interior [15]. Recognizing the earth resources information problem, RALI's authors establish the need for greater coordination and sharing of information concerning land and resource use. It is important to note that the RALI effort is concerned with data and information from existing conventional sources as well as from remote sensing sources. Structurally RALI would consist of a national facility in Washington, ten regional facilities, and centers at the state and local levels. Users would be able to enter the system at any one of the three levels. Common to all centers would be a reference service, that is, a directory of the pertinent data and information holdings of public and private organizations. The regional centers, strategically placed in already defined federal administrative areas would be federally supported. These centers would carry on the bulk of the storage and analytical processing effort. The regional facilities would also serve as the key roles in the information transfer network. One major technical barrier to

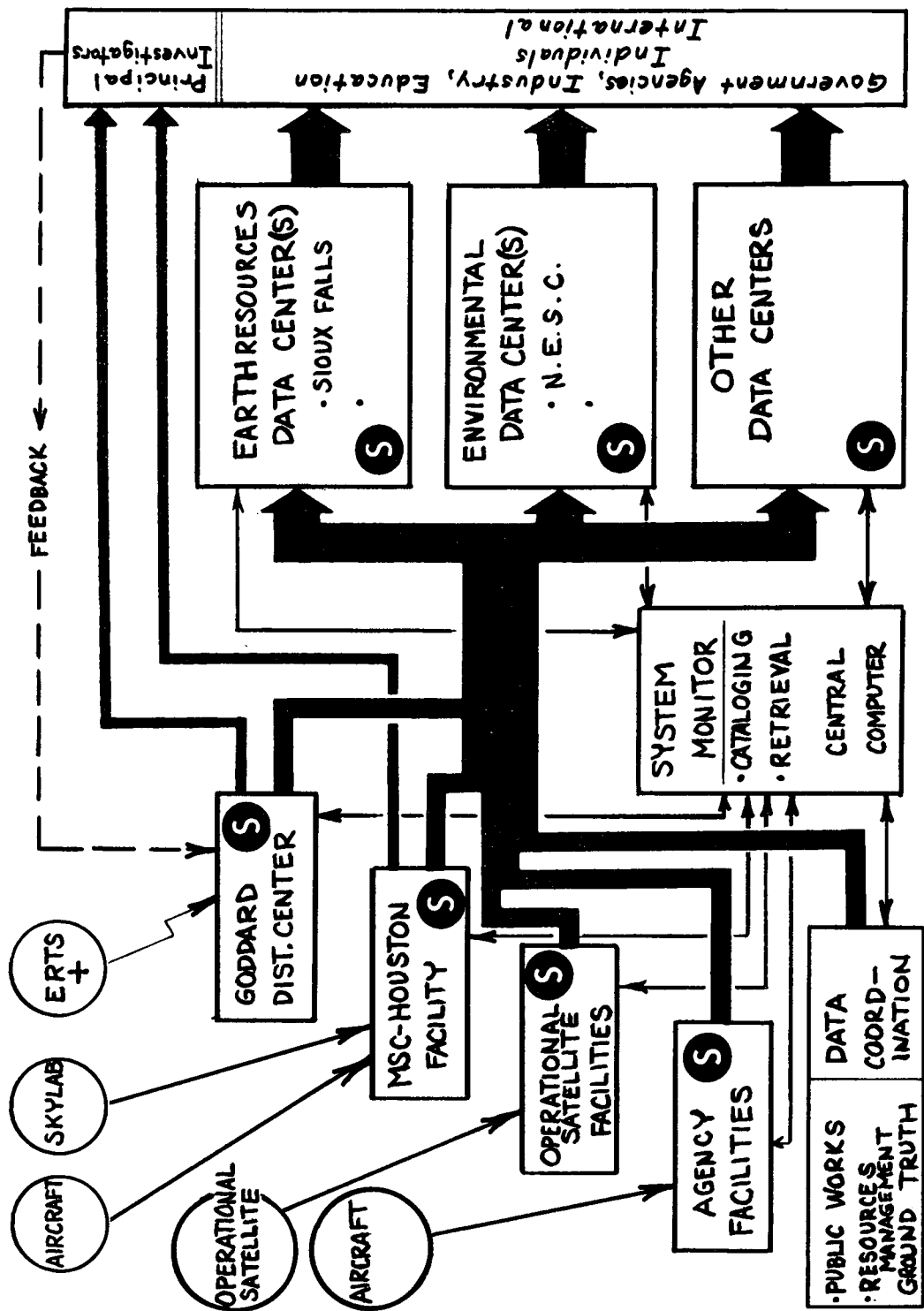


EXHIBIT I-7: ERSP DATA HANDLING SYSTEM -- EARLY OPERATIONAL PHASE [13]

this exchange is the lack of commonality among the computer equipment and data formats employed by the states. Overcoming this barrier will be one of the tasks of a proposed National Information Technology Office. In addition, this office would conduct research in data collection techniques, information storage, processing, retrieval, and display. A strong user orientation would pervade the RALI network -- thus the emphasis is on providing output consistent with the user's needs and his capabilities. At the time of this writing, government agencies in six states are being surveyed with regard to their needs and their assessment of the RALI concept. Preliminary findings concerning user needs confirm the often-stated difficulty of getting potential system users to specify their needs without having sample system output to examine.

Exhibit 1-8 presents an overview of RALI program elements. The Department of the Interior staff working on the RALI Program point out its heritage in the plan for a National Water Data Exchange (NAWDEX) [16]. This plan is illustrated in Exhibit 1-9. Because of the confined subject matter of NAWDEX and the existence of applicable data base management programs, the prospects for implementation of NAWDEX, once approved, seem favorable.

The reader may have noticed that the scope of RALI -- land use and natural resources -- is narrower than the scope of earth resources as delineated in section 1.1.1. The RALI scope is explainable in terms of the present agency charter of the Department of the Interior. To give RALI a wider purview would result in infringing upon the charters of other agencies, such as that of the Department of Commerce. Note, however, that a proposal for a Department of Natural Resources exists. Its scope, see Exhibit 1-10 [17], is more compatible with the earth resources definition. The Department would embrace most of the agencies now in the Department of the Interior, the Forest Service and the Soil Conservation Service from the Department of Agriculture, the civil works planning functions of the Army Corps of Engineers, the civilian power functions of the Atomic Energy Commission, and the National Oceanic and Atmospheric Administration from the Department of Commerce. Assuming the Department of Natural Resources were to be created, RALI could expand to a full-fledged earth resources information management system. A convincing proposal for a national earth resources information management system would tend to support the argument for a Department of Natural Resources.

1.6 WORK OF THE 1972 NASA/ASEE AUBURN DESIGN GROUP

The conceptual design of an information management system for earth resources was the project set before the authors of this report. It was the vehicle by which the authors, as program participants, would gain facility in the use of the systems approach. Not only was this

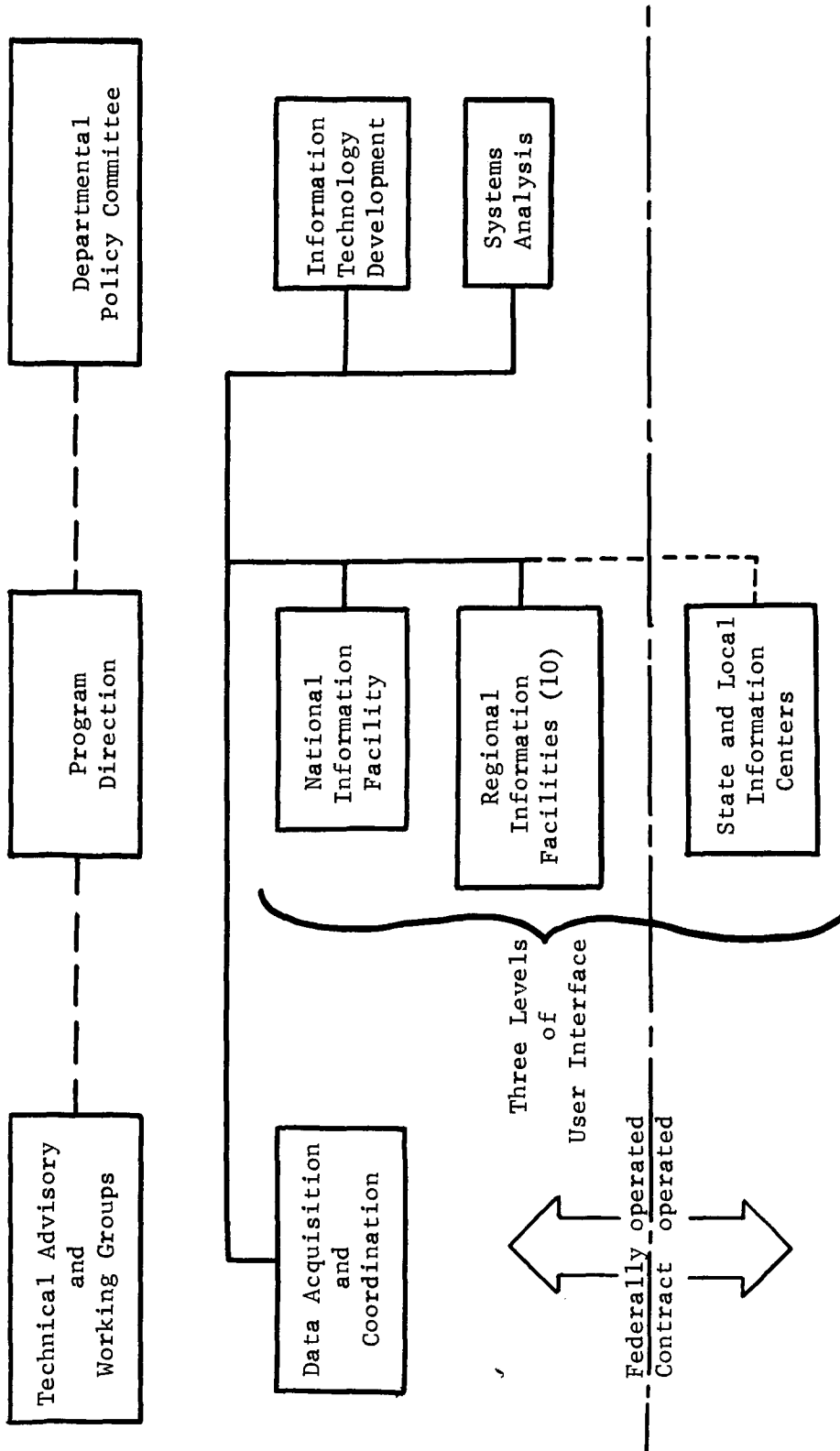


EXHIBIT I-8: FUNCTIONAL ELEMENTS OF THE RALI PROGRAM [I5]

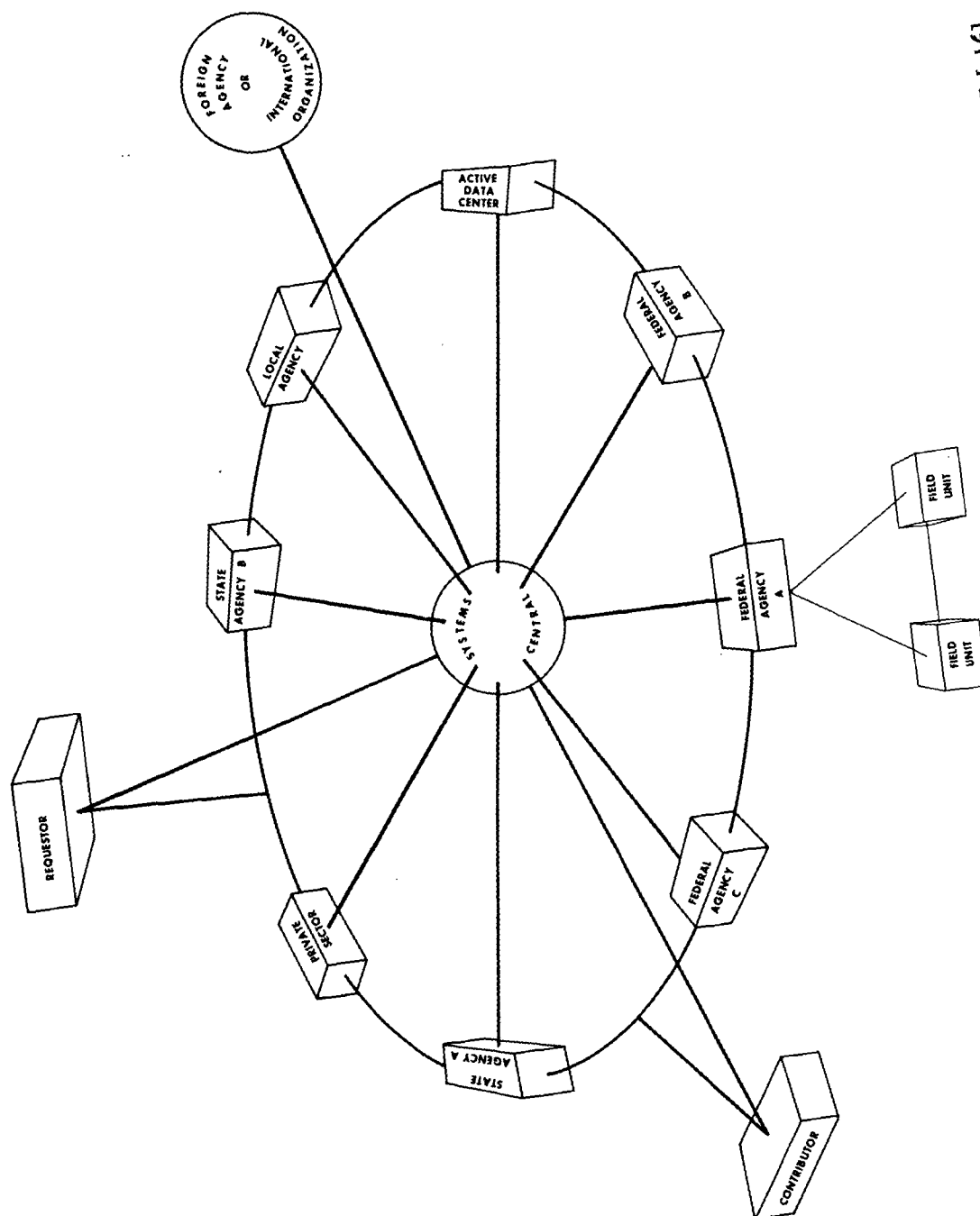


EXHIBIT I-9: LINKAGE OF UNITS IN THE NATIONAL WATER DATA EXCHANGE [16]

Proposed Department of Natural Resources

Secretary
Deputy Secretary

Assistant Secretary
for
Research & Development

Under Secretary
for
Management

Under Secretary
for
Policy

General
Counsel

Administrator for
Land and
Recreation Resources

Manage Federal Lands
Including Forests
Lease Federally Owned
Minerals
Prepare Nationwide
Recreation Plan
Manage National Parks
Wildlife Refuges and
Fish Hatcheries
Conduct Research and
Development

Administrator for
Water Resources

Develop Water Resources
Survey, Plan, Construct
and Operate Water
Resource Projects
Market Electric Power
Administer Grants to
States and Localities
Conduct and Support
Research and
Development

Administrator for
Energy and
Mineral Resources

Assess Resources
Operate Uranium Raw
Materials and
Enrichment Program
Conduct and Support
Research and
Development
Oversee Mine Health
and Safety

Administrator for
Indian and
Territorial Affairs

Conduct Programs for
Betterment, and Protect
the Rights of
— Indians
— Alaska Natives
— Territorial People
Manage and Develop
Assets in Trust

Administrator for
Oceanic, Atmospheric,
and Earth Sciences

Observe, Record, and
Analyze Atmospheric,
Oceanic, and Terrestrial
Data
Forecast Weather and
Other Physical
Phenomena
Conduct Surveys and
Mapping Activities
Assist State and Localities
Through Grants and
Cooperative Programs
Conduct Research
and Development

Regional Directors

EXHIBIT I-10: PROPOSED DEPARTMENT OF NATURAL RESOURCES [I 7]

training aim fulfilled but the participants also acquired knowledge concerning other important areas such as remote sensing, information processing, earth sciences, and pattern recognition.

1.6.1 Systems Approach to the Design Problem

A system is a set of inter-related items plus their interactions, internally, and externally with an environment, for some purpose. The value of the system concept is that it forces recognition of vital components, interactions, and the importance of environmental context.

The systems approach carries the system concept into the realm of problem-solving and design. The details and philosophy of the approach have already been covered in the Preface. While the systems approach is a highly useful method of problem solving, excessive "worship" of the method can lead to a loss of perspective of the problem itself. (The group, hopefully, managed to maintain a proper perspective). The diffusion of the systems approach and analysis concept has been greatly fostered by NASA (e.g., [17]) and so represents a significant contribution of technology transfer to the public domain.

The diagram serving as the lead-in to this chapter depicts the Design Group's treatment of the problem via the systems approach. Four major subsystems following the outline of the UNISTAR Report [7] were identified and made the basis for task group objectives:

- Sources
- Processing
- Users
- Management.

System level constraints and criteria were formulated for the evaluation and trade-off of alternatives developed. The more crucial of these constraints and criteria, listed in the diagram fronting this chapter, are:

User-oriented: To be effective and successful an IMS must provide users with data and information that meets their needs. This implies that needs must be continually monitored and tailored "products" created.

Adaptable: Information needs change, information supplies (quality and quantity) change, as does the context in which a system finds itself. An IMS should respond and adjust to these changes.

Compatible: A wide variety of data and information sources, services, and systems already exist or are emerging. Any newly-created IMS should be consonant with all of these. Indeed, its presence should enhance the present and prospective suppliers of data and information.

A full list of system-level criteria and constraints is discussed in more detail in section 6.1.1.

The outcome of the primary round of evaluation and trade-off was a conceptual earth resources information management system that was dubbed ERISTAR -- Earth Resources Information Storage, Transformation, Analysis and Retrieval. The UNISTAR Report, cited earlier, made a strong recommendation for the establishment of a national information management system for scientific and technical information as a national policy. This report -- the ERISTAR Report -- translates that recommendation to the mission level. A national information management system is needed for the important mission of sound resource management.

1.6.2 A Solution -- The ERISTAR System

In brief the ERISTAR system is the presently loose collection of existing and emerging information sources, services, and systems concerned with earth resources interlaced with a hierarchical network of ERISTAR centers. The hierarchy works down from a national ERISTAR center through regional, state, and where appropriate, sub-state centers (Exhibit 1-11). The primary aim of the ERISTAR center network is thus to act as an integrative force. ERISTAR centers would in no way replace existing agencies -- federal or state. Indeed, it is conceivable that in certain instances an ERISTAR center may actually reside in an established organization. ERISTAR centers will not gather primary data, but will instead rely on other bodies to carry out this important task. The centers will, however, spend considerable effort in translating user requests and problems such that pertinent responses and answers can be provided. Another important activity of the ERISTAR center will be the tapping of existing sources, services, and systems. Information analysis centers are expected to be important contributors to the ERISTAR center network. On-site data storage and processing at an ERISTAR center will be geared to requests of a recurring nature and confined to problems usually associated with that level of the hierarchy (these derive mainly from the center's defined geographic scope).

Also incorporated in the ERISTAR network is a set of communications and information technology support facilities. These aid ERISTAR centers in developing data gathering techniques and in keeping pace with advances in the state-of-the-art in pertinent technologies.

Implementation of the ERISTAR system concept can be gradual with the initial unit or model center serving as "proof of concept". A time-phased development plan has been outlined. Details on the design and the plan are presented in chapters 6 and 7 respectively. Other important recommendations and conclusions associated with the ERISTAR concept appear in Chapter 8.

EXHIBIT I-II: AN OVERVIEW OF ERISTAR

Earth Resources Information Storage Transformation Analysis and Retrieval

Def: User-oriented IMS

Scope: Earth resources

Structure: Hierarchical Network of:

State centers	}	Linked to existing systems
Regional centers		
National center		

Supplemented by a network of
Communication and Information Technology
Support Facilities (e. g., MSFC)

Implementation:

Model ERISTAR center	}	Concurrently with a National center
to		
State center		
to		
Regional center		

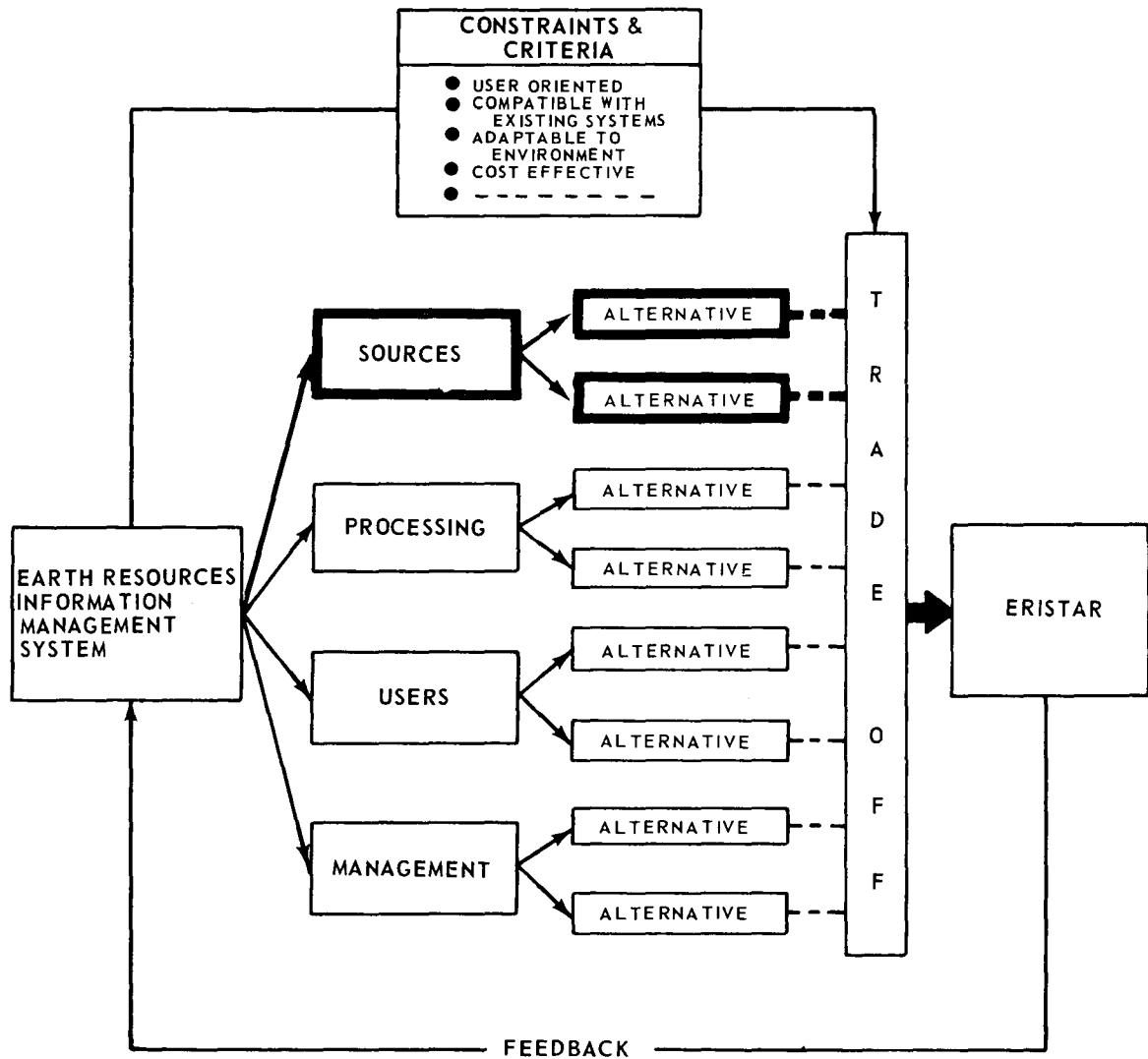
1.7 A POSITION STATEMENT

While the ASEE Auburn Design Program has been supported by NASA, NASA has not attempted to shape the design outcome. The faculty participants jealously guarded the principles of objectivity and independence of thought. Their advocacy of a system that begins with the states is based on many contacts with state and regional officials during the design program. At the federal level a multi-agency perspective was maintained. In the judgement of the authors, the ERISTAR network is a realistic, workable solution to the information problem in earth resources management. ERISTAR should also serve as a guide to the resolution of information management problems in other scientific and technical areas. The authors urge its implementation.

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2. "UN to Set up IR Service for Environment", Information Retrieval and Library Automation Letter, Vol. 8, No. 2 (July 1972).
3. Zissis, George J., "The Development of Remote Sensing of Earth Resources", Remote Sensing of Earth Resources, Papers of the 13th Meeting of the Panel on Science and Technology, Committee on Science and Astronautics, U. S. House of Representatives, Washington, D. C.: U. S. Government Printing Office, 1972, pp. 119-128.
4. Remote Measurement of Pollution, NASA SP-285, Washington, D. C.: Scientific and Technical Information Office, NASA, 1971, pp.40-41.
5. Earth Resources Satellite System, A Report by the Subcommittee on Space Science and Applications to the Subcommittee on NASA Oversight, Committee on Science and Astronautics, U. S. House of Representatives, Washington, D. C.: U. S. Government Printing Office, 1968.
6. Thiel, A. K., "Requirements and Technology for Observations from Space", Remote Sensing of Earth Resources, Papers of the 13th Meeting of the Panel on Science and Technology, Committee on Science and Astronautics, U. S. House of Representatives, Washington, D. C.: U. S. Government Printing Office, 1972, pp. 47-48.
7. UNISTAR (User Network for Information Storage, Transfer, Acquisition, and Retrieval), Report of the 1970 NASA/ASEE Summer Systems Design Program, Marshall Space Flight Center and Auburn University.
8. COSATI, The Management of Information Analysis Centers (Proceedings of a Forum), Springfield, Va.: National Technical Information Service, 1972, (Report No. PB 208018).
9. COSATI, Directory of Federally Supported Information Analysis Centers, Springfield, Va.: National Technical Information Service, 1970, (Report No. PB 189300).
10. CODASYL (Conference on Data Systems Language), Data Base Task Group Report -- April, 1971, New York: Association for Computing Machinery.
11. National Academy of Sciences - National Research Council, Division of Engineering, Useful Applications of Earth-Oriented Satellites, Washington, D. C.: NAS, 1969, Panel 1 Report, p. 20.

12. TRIAD (Tellurian Resources Inventory and Development), Report of the 1969 NASA/ASEE Summer Systems Design Program, Langley Research Center and Old Dominion University.
13. Ad Hoc Study Group on the Earth Resources Survey Program, Report on the ERSP, Washington, D. C.: National Aeronautics and Space Council, March 10, 1971, 3 vols.
14. Jaffe, L. and Summers, R. A., "The Earth Resources Survey Program Jells", Astronautics and Aeronautics, April 1971, pp. 24-40.
15. Resource and Land Information (RALI): Program Description, U. S. Department of the Interior, June 29, 1972, 22 pages.
16. Federal Advisory Committee on Water Data, Design Characteristics for a National System to Store, Retrieve and Disseminate Water Data, Washington, D. C.: U. S. Geological Survey, Office of Water Data Coordination, Oct. 1971.
17. Council on Environmental Quality, Environmental Quality, 2nd Annual Report, Washington, D. C.: U. S. Government Printing Office, Aug. 1971.
18. Applications of Systems Analysis Models, NASA SP-5048, Washington, D. C.: Office of Technology Utilization, NASA, 1968, 69 pages.
19. Aines, Andrew, Remarks made at a NASA/ASEE Design Group Seminar, August 2, 1972 at the Marshall Space Flight Center, Huntsville, Alabama. (See Appendix F-2 for further details.)
20. Committee on Scientific and Technical Communication, National Academy of Sciences--National Academy of Engineering, A Pressing National Problem and Recommendations for its Solution (The "SATCOM Report"), Washington, D. C.: NAS, 1969.

2. SOURCES



This chapter will discuss how a comprehensive information management system for earth resources, such as the ERISTAR system, should handle sources and the accompanying problems. As shown in Exhibit 2-1, the sources subsystem is one of four comprising the design requirements for an earth resources information management system. Exhibit 2-2 displays the initial application of the systems approach to the sources subsystem itself. Exhibit 2-4 provides a more detailed breakdown and will serve as framework for the discussions in this chapter.

2.1 BACKGROUND

The design of an information management system for earth resources must consider the utilization of data and information from a wide variety of sources. In addition to the aircraft and satellite remote sensing programs (ERTS A and B, Skylab, etc), numerous federal and state agencies have resource-related programs serving the public. At the federal level the agencies include the Departments of Agriculture, Commerce, Interior, Transportation, and the Corps of Engineers. To support these services each agency has developed an organization to collect and analyze data, and to distribute the information product. Likewise, each state has established agencies for collecting and analyzing earth resource data and for distributing the information through prescribed channels. To a lesser degree counties and municipalities also generate relevant data and information on earth resources. Thus the potentially available amount of data and information is enormous, especially when one considers the "dusty files" containing pertinent information that presently does not enter into information transfer channels. In addition, there are many properties of the earth resource data which present great problems to a comprehensive information management system -- size, diversity of form, content and rate of generation, and difficulties of access.

2.1.1 Basis For The Requirements Analysis

Overall system design criteria (section 6.1.2) emphasize the importance of strong user orientation. Accordingly the examination of the requirements for sources should begin with user needs and work back. Exhibit 2-3, as read from right to left, shows that user problems or needs translate into a desire for some "data-information product" which he can apply to the resolution of that problem or need (Appendix A-4). (At this point it might do well to emphasize that the distinction between data and information can best be drawn by the user and not by the "supplier".) Note that the translation from need to information product desire may not be obvious and explicit. Therefore an important task for the supplier is to aid the potential user in articulating his data and information needs. By providing an information product the supplier has effected information transfer. More properly, information transfer really takes place only when a user is able to effectively apply the information product provided to his problem.

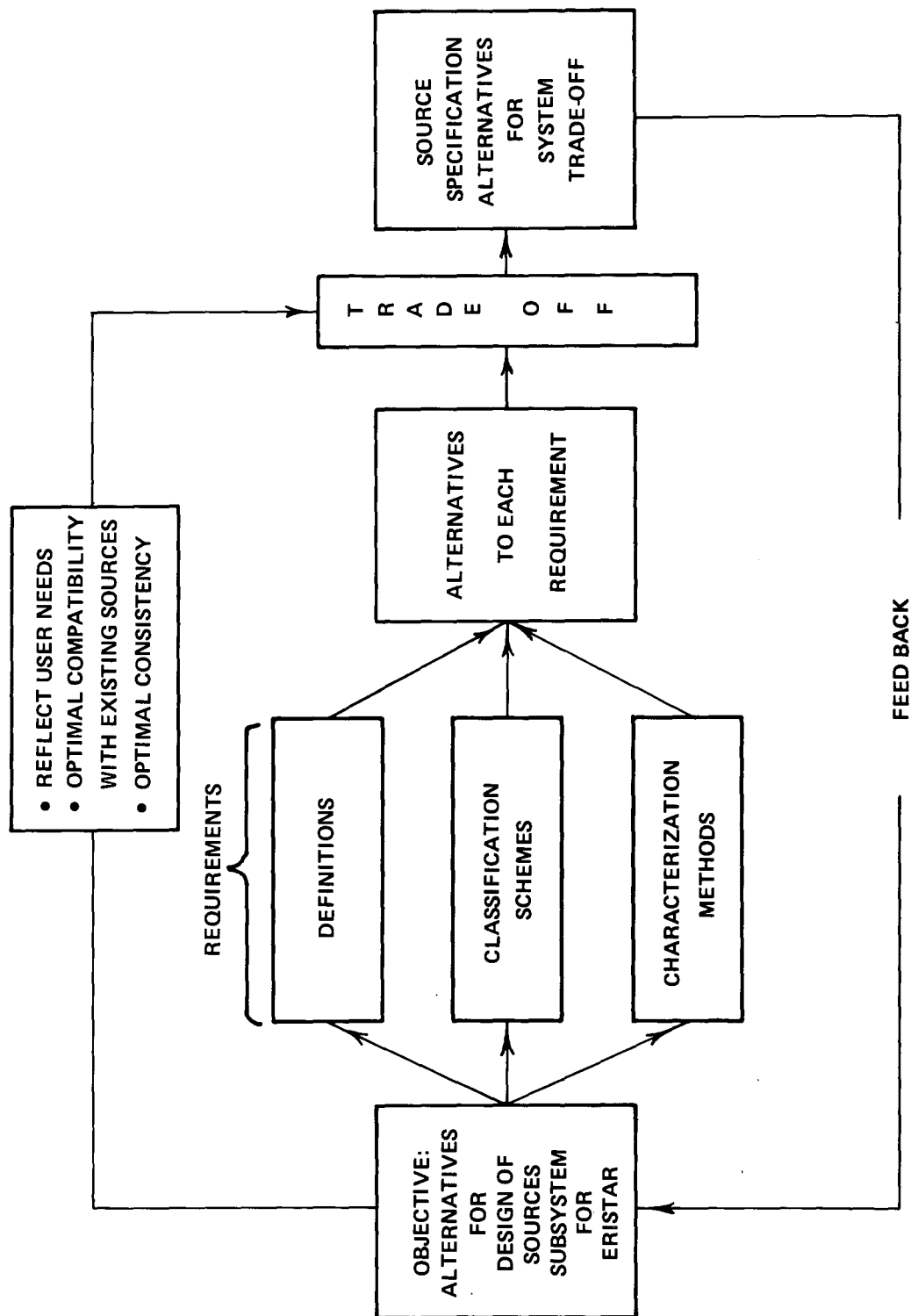


EXHIBIT 2-2: SOURCES SUBSYSTEM DIAGRAM

For the supplier the task of creating the proper information product is one of information transformation. That is, the supplier marshals and blends available and specifically generated data and information with an eye on user needs, incorporating feedback where appropriate. In many cases the products are generic and so serve the needs of a number of users (e.g., the compilation of an atlas of thematic maps, Appendix A-4). At other times the product will be tailored to the specific needs of one user (e.g., imagery showing the distribution of blight in a corn field). Appendix A-1 provides further illustrations of transformation.

What must a supplier know about data and information sources so that he can "marshal and blend" them? First he must know what is to be included in the sets of sources pertinent to his customers. That is, he must have definitions. To be efficient in his transformation efforts he must have classifications of those sources. (Classification of user needs and applications is similarly important to information transfer.) And to actually use data and information sources the supplier must have characterization methods. These three terms are defined below and form the key requirements for the sources subsystem of an information management system for earth resources.

2.2 REQUIREMENTS AND ALTERNATIVES

A more rigorous restatement of the material from the prior section is as follows:

Definition is the delineating of the scope of earth resources data and information sources, i.e., what is to be included in the sources sets.

Classification is the process of structuring source types to maximize their utility to the information management system.

Characterization methods entail detailing the properties of the source data in order to describe the input requirements for the information management system.

In elaborating upon these requirements and their alternatives, it is necessary to discuss their associated criteria, (Exhibit 2-4).

2.2.1 Definitions - First Requirement

They should not only reflect established and anticipated user needs, but should also be compatible and consistent with existing definitions. Two alternatives exist when considering earth resources definitions: broad and narrow. Since a formal definition was not found in the literature scanned, the following was formulated:

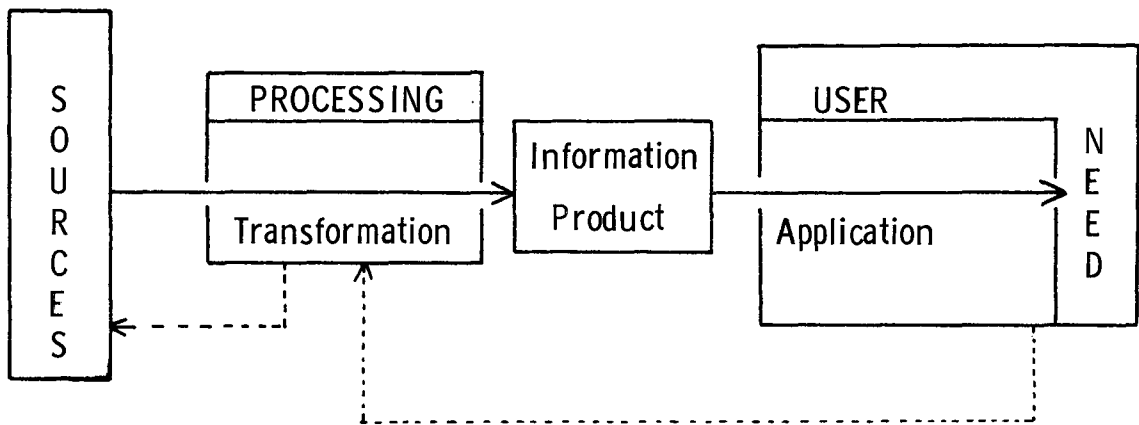


EXHIBIT 2-3: OVERVIEW OF INFORMATION FLOW -- SOURCE TO USER

Earth resources are those parts of the natural and man-made physical environment which are presently or potentially useful to man.

Of course this is a very broad definition. The inclusion of man-made elements in the definition distinguishes natural resources as a subset of earth resources. For example, an irrigation system is not a natural resource but is an earth resource. In support of the broad definition alternative NOAA Administrator Dr. Robert M. White states that:

"...atmospheric observations usually are not included in discussions of remote sensing of 'earth resources'. Yet the atmosphere is one of man's most important resources -- it's costly at best to sustain life without it, and most human activities are weather sensitive. Even considering the oceans, our objective is rational resource management, not only in the extraction of living and mineral resources but also in environmental aspects of the oceans as they relate to man's activities and in preserving the ocean environment for future generations." [1]

The second alternative is that of the narrow definition. In this instance earth resources are usually thought of only as natural resources, for example, copper, petroleum and coal resources. Certainly, an information management system for earth resources should encompass the broader definition that has been presented.

The difficulty of defining "source" is not unlike that in the previous discussion. The words "source" and "resource" are, of course, related-- both derive from French words for "rise". "Source" will be used to indicate a systems environment element that actively or passively becomes an input to a system. A source itself can receive inputs, i.e., "sources can be users and users can be sources."

2.2.2 Classification Schemes--Second Requirement

The criteria applied to selecting classification schemes can be expressed as follows: (a) orthogonality (classes which are fundamentally different from each other or mutually exclusive) and (b) hierarchical (i.e., logical, nested subdivision sequences). In constructing classifications within this framework two major alternatives arise: single and multi-factor classifications. Before proceeding into a discussion of the two alternatives, it may be helpful to present some ways of classifying sources according to the following factors:

- o Scientific discipline
- o Mode of man's interaction with the resource
- o Anticipated application or purpose of the data and information

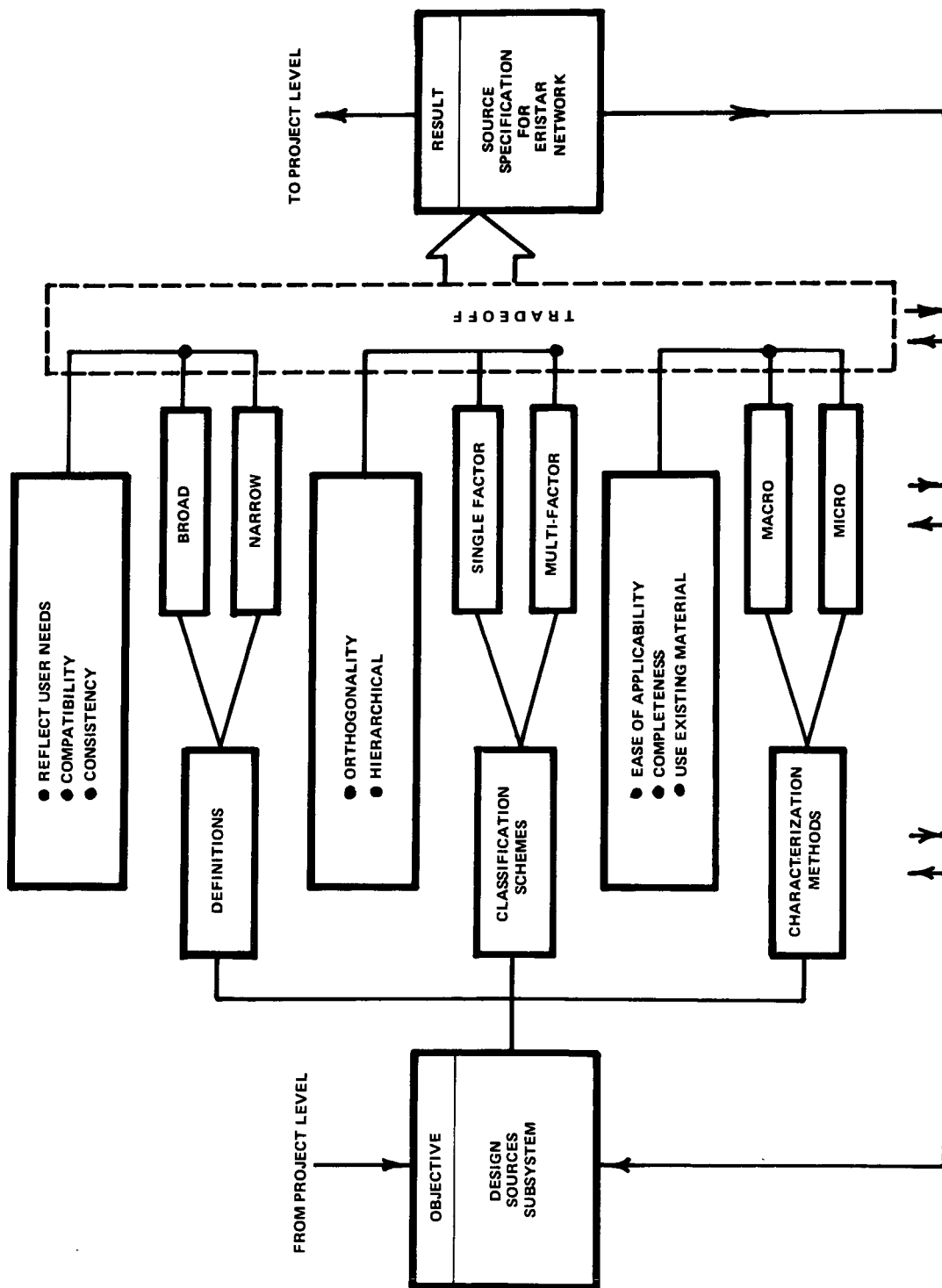


EXHIBIT 2-4: DETAILED SOURCES SUBSYSTEM DIAGRAM

- o Form in which the data and information appear
- o Location to which they pertain
- o Time period covered
- o Originator of the data and information
- o Method of their compilation
- o Residence of the source
- o Manner of accessing the data

A single factor classification may be one that is based solely upon any one of those listed above, each as form or location. A multi-factor classification is one which is based upon two or more of the listed factors. Hierarchical expansion of the classification category (Exhibit 2-5) provides a relational structuring of the source data into elements that can be appropriately selected and combined into informational categories satisfying the user request to the information system.

Other important sources categories can be found in existing data and information supplier types (Exhibit 2-6). These are directly pertinent to the discussion of an information management system for earth resources. They are the:

data center - An organization primarily for acquiring, analyzing, processing, storing, retrieving and disseminating data, e.g., a center for processing raw data received from artificial satellites; or a center for collecting and compiling processed data on thermo-properties of materials.

document center - An organization primarily limited to selecting, storing, or retrieving documents, and disseminating only in response to requests as unique numbers. The document center disseminates the documents delivered to it, or facsimilies of them.

documentation center - An organization that performs all the functions of a document center, and, in addition, announces, abstracts, extracts, and disseminates documents in response to requests expressed as accession numbers, subjects, authors, etc. The output of the center consist of documents, indexes, bibliographies, catalog cards, etc.

information analysis center - An organization established primarily for acquiring, selecting, storing, retrieving, evaluating, analyzing, and synthesizing information in a clearly defined

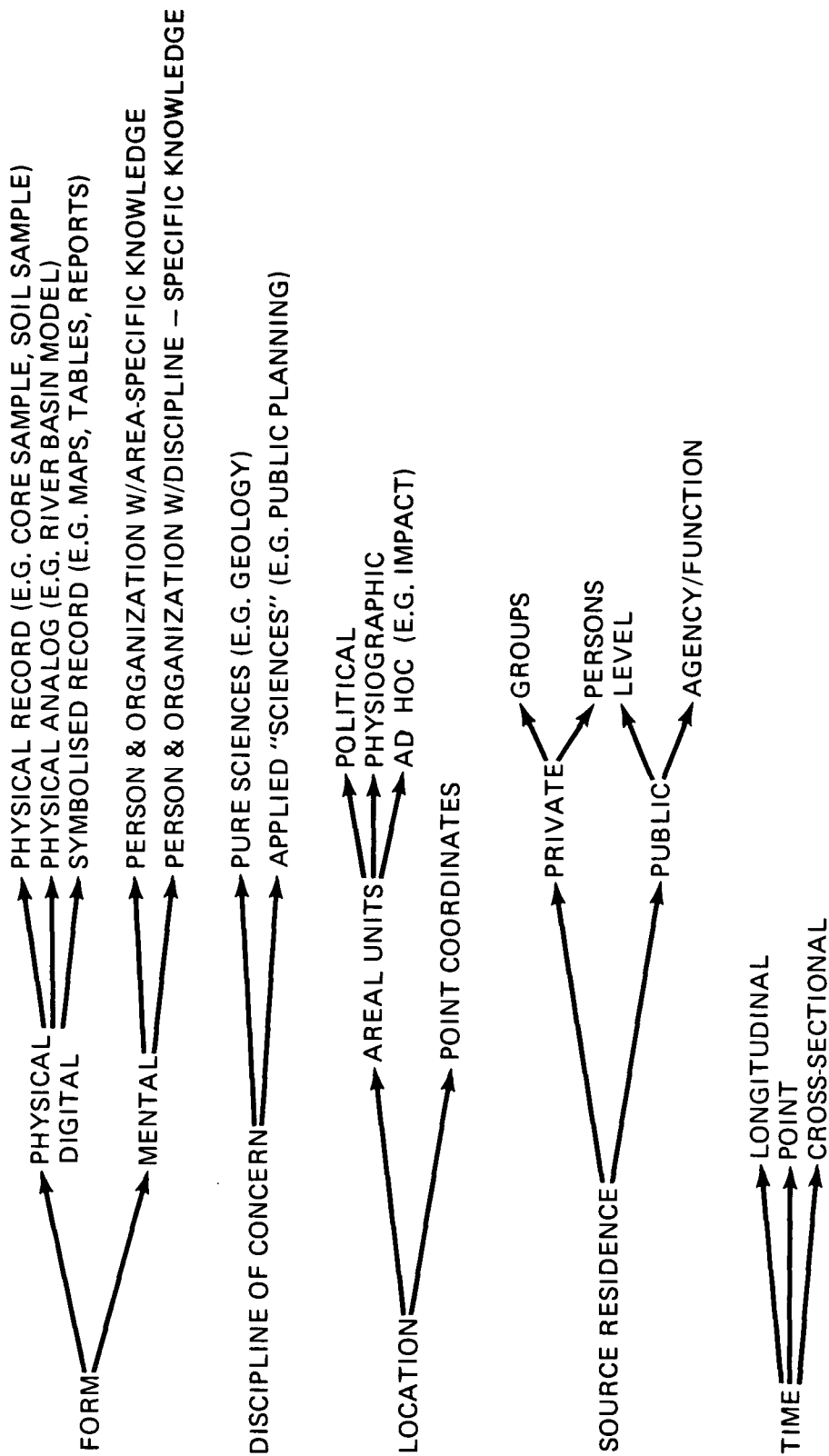


EXHIBIT 2-5: SUBDIVISION OF SELECTED SOURCE CLASSIFICATION FACTORS

<u>NAME</u>	<u>FUNCTION</u>	<u>PROPERTIES</u>
Documentation Center	2, 4	G, S, N
Document Center (e. g., library)	2, 5	G, S, N
Information Analysis Center	1, 5	S, N
Information Evaluation Center	6, 1	S.
Information Clearinghouse Center	2, 7	S.
Referral Center	3, 7	G, S
Scientific and Technical Info. Center	1, 2, 3, 4, 5, 7	S, N

LEGEND:

<u>FUNCTIONS</u>	<u>PROPERTIES</u>
1. Review or Analysis	General - G
2. Handling Documents	Specific - S
3. Directing Searches	Network - N
4. Announcements	
Abstracts	
Extracts	
Document Dissemination	
5. Current Awareness (SDI)	
6. Evaluation	
7. Referral	

EXHIBIT 2-6: INFORMATION SYSTEMS TYPES

specialized field, or pertaining to a specific mission with the intent of compiling, digesting, repackaging, or otherwise organizing and presenting pertinent information in a form more authoritative, timely, and useful to a society of peers and management.

referral center - An organization for directing searches for information and data to suitable sources such as libraries, information evaluation centers, document or documentation centers, and individuals. A referral center does not supply documents or data.

scientific and technical information center - An organization that collects, reviews, digests, analyzes, appraises, summarizes, and provides advisory information and data in a well-defined specialized field. A center exclusively concerned with review and analysis is an information analysis center.

It is noted that a supplier could be a combination of two or more of the listed centers. Such a unit will be termed a hybrid.

2.2.3 Characterization Methods -- Third Requirement

2.2.3.1 Introduction

As stated above, source data characterization entails detailing the properties of the source data in order to establish the input requirements for the information management system. When the user specifications are similarly detailed, the appropriate processing function can be selected to transform the source data into the information product. For example, to satisfy a user request for a land use classification map of a specified area, the correlative source data may be accessed in one of several forms. If land use maps have been prepared for the area specified, the map is the source data; query analysis and processing thus involve a document-type search of the library files, done by means of a geographical classification coding, and the selection of the appropriate map is according to its identification code. This processing may or may not involve a computer search, depending on the size, nature and complexity of the document data base. However, if no land use map exists, the source data might well be remote sensing imagery of the specified area, and the query analysis and processing might, for example, direct the user to the EROS Data Center where a search can be made for the appropriate imagery. Alternately, the supplier might have the capability to create a land classification map from remotely sensed and ground based information available from other sources (See Appendix A-2).

The above example serves to illustrate the several possible paths of information flow that likely would be part of the design and implementation of any large information management system. The paths are from user to system to source data to processing to user. These may

well include relatively simple querying of referral lists which direct the user to a person or organization that can provide an answer to the query. The sophistication level here is low, and the sources specifications requirements are mathematical strings of identification information. A telephone directory has this form and structure. A much higher level of system sophistication is necessary to satisfy the user by means of automatic map production; this involves analysis of the query, selection of data elements from various data bases, and analysis and synthesis of the data and display in the form of maps. The data structures in this situation are much more complex, being organized into trees, graphs and networks. The search and retrieval of the document (map) is of intermediate complexity, the search paths being directed through the map information descriptors within a thesaurus having a hierarchical tree structure. It is therefore important to note that as the sophistication or complexity of an earth resources information management system (such as the proposed ERISTAR) evolves so does the need for broader characterization of data and information sources. And similarly, as a given information management system evolves from the design stage to actual implementation the characterization of sources needs to become more complete.

2.2.3.2 Specification

The criteria for earth resources definition and classification functions lead to two options for characterizing methods for sources specification (Exhibit 2-4). Micro specification alludes to the procedure of defining sources in terms of their most elemental components - the data elements. Macro specification alludes to the description of large information elements.

The principal means of sources characterization in this report are in the form of organization directories, profiles, and tableaus (Exhibit 2-7). A directory is a listing of organizations having earth resources data and information and emphasizes basic identification data. Arrangement may be alphabetical by name and/or other key words. A profile adds detailed description to a basic directory entry--categories used in profiles are shown in Exhibit 2-8. Published directories and collections of profiles are available to assist developers of earth resources information management system [3]. The recently-published Encyclopedia of Information Systems and Services [4] is especially helpful in this regard. The next two numbered sections are profiles of actual sources. Note the difference in depth of detail.

A tableau combines information on data content within organizations in terms of discipline classification categories and the form in which the data are collected. It is important to differentiate between physical copy and digital forms of data collections in order to specify equipment criteria for the information system design. Moreover, the discipline categories must be detailed to the level necessary for

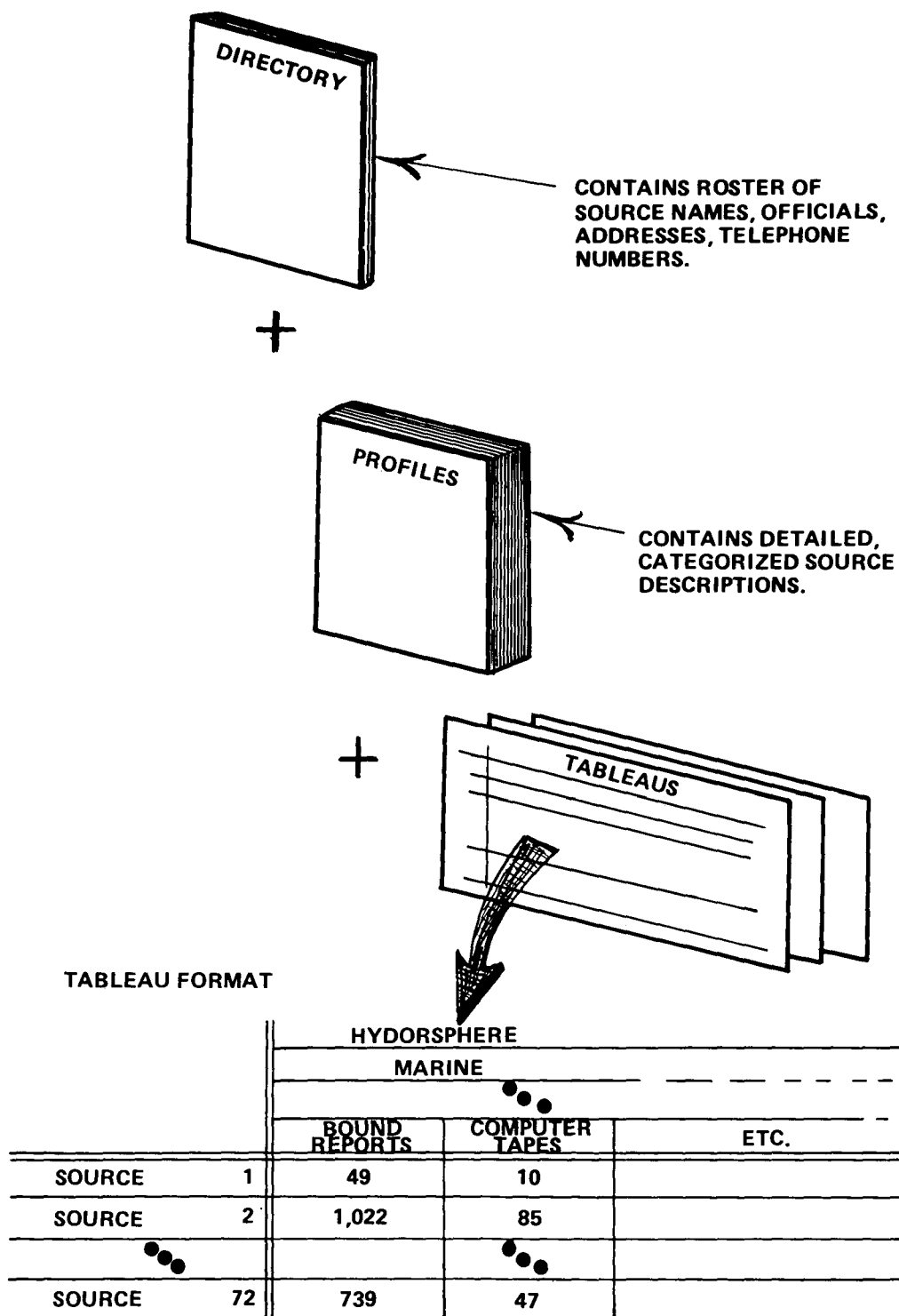


EXHIBIT 2-7: CHARACTERIZATION METHOD DEVICES

- . basic identification (Name, address, etc.)
- . officials
- . sponsor
- . date established
- . staff
- . mission, objective
- . background
- . description of system or service
- . scope, subject coverage
- . input sources
- . holdings
- . publications
- . computer-compatible offerings
- . other services
- . computer and information processing equipment
- . User restrictions

EXHIBIT 2-8: TYPICAL CATEGORIES EMPLOYED IN THE PROFILING OF DATA AND INFORMATION SYSTEMS AND SERVICES

production of the information product specified by the user. Thus, if hardness of ground water is an information element needed for the information product, the hydrosphere category must be expanded to include chemical analysis of ground water. The tableau ultimately must have this form.

2.2.3.3 Profile of EISO

Environmental Information System Office (EISO)
Oak Ridge National Laboratory
Oak Ridge, Tenn. 37830
Tel: (615)

Director: Gerald U. Ulrickson

Sponsor: Division of Research, Atomic Energy Commission

Year Started: 1971

Staffing: Still in process

Mission and Scope: To link together several specialized environmental information centers (Project support centers) and a variety of specialized data bases. The staff includes research scientists who have special knowledge of recent research and can assist in evaluating the significance of recent findings.

Services: A computerized directory of information centers, research projects, and individual investigators exists to serve research administrators, scientists, group leaders, and information specialists who have an immediate need for communication with other active workers in the environmental fields.

Specific EISO affiliated information centers include: the Ecological Sciences Information Center (ESIC) which provides bibliographic reference of data relevant to the movement, cycling, and concentration of elements, isotopes, natural compounds, and pollutants in different ecosystems; the Environmental Mutagen Information Center (EMIC) which organizes information on mutagenesis caused by pollutants from various sources; the Eastern Deciduous Forest Biome Information Center (International Biological Program) which collects, stores, and retrieves meteorological data, primary and secondary productivity data, phenomenological data, and hydrological data relative to sites within the Biome; and the Toxicology Information and Response Center (TIRC) which stores and disseminates information on the nature and effects of toxic materials.

In addition, several other EISO specialized data bases exist in various stages of development. These include the Toxic Materials in the Environment data base, the Social Sciences data base, the Regional Modeling data base, the Energy Research data base, the Materials Resources and Recycling data base, and the HUD Solid Waste data base. These data bases are described further in [6].

Qualified Users: Qualified workers in the fields described above. It is expected that charges to users will be imposed on a cost-recovery basis.

2.2.3.4 Profile of The EROS Data Center

2.2.3.4.1 Mission Scope

One of the principal emerging sources of earth resources data is the EROS Data Center in Sioux Falls, South Dakota. The synoptic view afforded by both satellite and aircraft imagery available at the Center is of value to a multitude of disciplines operating in the four resource categories (Atmosphere, Hydrosphere, Lithosphere, and Biosphere) depicted in Exhibit 1-2.

Basically, the EROS Data Center is a Department of the Interior public service organization combining the elements of a high quality photo laboratory with the facilities for imagery storage, retrieval, reproduction, and dissemination, and for user assistance and training to a limited degree. Items available for purchase include Earth Resources Technology Satellite (ERTS) imagery, NASA aircraft imagery, United States Geological Survey (USGS) Aerial photography, thematic maps, and other related products such as the data taken from the Data Collection System (DCS) platforms which support the ERTS principal investigators.

2.2.3.4.2 ERTS Imagery Data

The NASA Data Processing Facility (NDPF) at the Goddard Space Flight Center processes all ERTS imagery prior to delivery to Sioux Falls. A description of the Return Beam Vidicon (RBV) and Multi-Spectral Scanner (MSS) imaging sensors aboard the spacecraft is available in the Earth Resource Technology Satellite (ERTS) DATA USERS HANDBOOK. The raw ERTS data are either bulk processed in the form of 70 mm film or precision processed and provided on film at a scale of 1:1,000,000. Only about 5 percent of the images available are precision processed which include rectification to truly orthographic photographs with superposition of the Universal Transverse Mercator (UTM) grid. Both individual images and color composites are standardized to 9 X 9 inch film positives, negatives, and paper prints. Some of the ERTS data (all of the precision processed data) are available on computer-compatible magnetic tapes.

2.2.3.4.3 NASA Aircraft Imagery Data

Imagery obtained by NASA as part of its Aircraft Program in support of the development of earth resources surveys is processed at the Manned Spacecraft Center (MSC). This imagery was acquired for specific purposes with varied specifications as to time, areal coverage, and sensors, and is primarily of test sites within the continental United States. A catalog of this imagery and a browse file are also at the EROS Data Center. Some of these data are also available on computer-compatible tape.

2.2.3.4.4 United States Geological Survey (USGS) Aerial Photography

Aerial photographs made by the USGS primarily for purposes of topographic and geologic mapping are available from the Data Center. The vast majority is black-and-white, vertical photographs at a scale of approximately 1:24,000, and contact prints are 9 X 9 inches. Because of the analyser's need to see the ground surface, these photographs are usually taken in the late fall or early spring. Coverage is of discontinuous areas throughout the coterminous U. S., Alaska, Hawaii, and the Territories. The remainder of the collection is either black and white, low oblique photographs, taken with cameras tilted approximately 20° from the vertical, or high-altitude photographs. Catalogs of the USGS photographs and a browse file for evaluation of coverage are available at the Data Center. A standard order for imagery type products from the Data Center is represented in Exhibit 2-9.

2.2.3.4.5 Thematic Maps

Thematic maps produced systematically or mechanically from ERTS imagery are available at the Data Center. The special subjects covered are extent of standing water, infrared-reflective vegetation, massed works of man, and snow cover. Maps are prepared for the entire United States or parts thereof if the subject, as for example, snow cover, is not applicable to the entire country. The maps are produced as single-color transparent overlays to a base map series, both with UTM grid to expedite registration. The subject data are extracted periodically for comparative purposes in order to detect changes in these dynamic phenomena. The data for the overlays are also available on magnetic tape.

2.2.3.4.6 Browse File

A browse file on 16 mm film is available to examine and locate items of interest to the user. The browse files have two indexes to identify scenes at high speeds, Kodamatic Indexer Code Lines and Image Control.

2.2.3.4.7 EROS Data Management System

Some of the primary functions of the data management system being developed at the EROS Data Center are to provide a computerized imagery

UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY TOPOGRAPHIC DIVISION



EROS DATA CENTER
SIOUX FALLS, SOUTH DAKOTA 57198

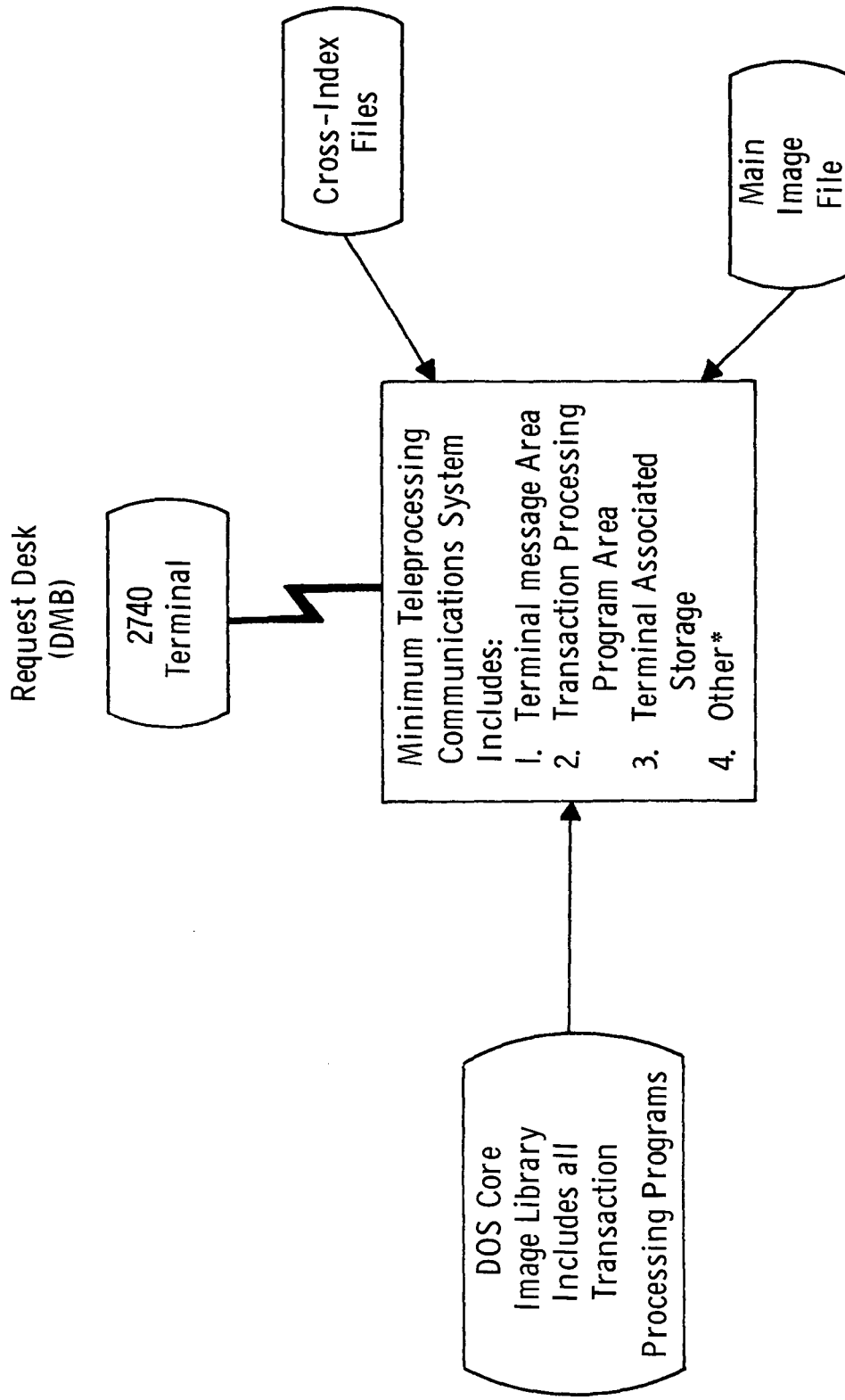
Name: _____
Address: _____

☐ Register Mark
Order Number _____
User Number _____

Phone: _____

<input type="checkbox"/> Same as preceding unit Number	First Frame: _____ EDC-Access Number _____	Last Frame: _____ EDC-Access Number _____	Total \$ _____ This Unit _____
	Product Desired No. of Copies per frame <input type="checkbox"/> Black & White <input type="checkbox"/> or Color <input type="checkbox"/> Negative or Positive <input type="checkbox"/> Film or Paper <input type="checkbox"/> Enlargement <input type="checkbox"/> Delivered in roll <input type="checkbox"/> or cut (flat) <input type="checkbox"/> Consecutive or Alternate frames <input type="checkbox"/> Dodged or Undodged <input type="checkbox"/> Highlights <input type="checkbox"/> Normal <input type="checkbox"/> Shadow <input type="checkbox"/> Enlargement Factor <input type="checkbox"/> * Rectify <input type="checkbox"/>		
	Printing Instructions Roll _____ Frame _____		
<input type="checkbox"/> Same as preceding unit Number	First Frame: _____ EDC-Access Number _____	Last Frame: _____ EDC-Access Number _____	Total \$ _____ This Unit _____
	Product Desired No. of Copies per frame <input type="checkbox"/> Black & White <input type="checkbox"/> or Color <input type="checkbox"/> Negative or Positive <input type="checkbox"/> Film or Paper <input type="checkbox"/> Enlargement <input type="checkbox"/> Delivered in roll <input type="checkbox"/> or cut (flat) <input type="checkbox"/> Consecutive or Alternate frames <input type="checkbox"/> Dodged or Undodged <input type="checkbox"/> Highlights <input type="checkbox"/> Normal <input type="checkbox"/> Shadow <input type="checkbox"/> Enlargement Factor <input type="checkbox"/> * Rectify <input type="checkbox"/>		
	Printing Instructions Roll _____ Frame _____		
ERT Satellite Images * Color Composite <input type="checkbox"/> Bulk Data <input type="checkbox"/> Prec. Processed <input type="checkbox"/>			
EDC Use Only Entire Roll <input type="checkbox"/> Format <input type="checkbox"/> Frame Equivalency <input type="checkbox"/> Film <input type="checkbox"/> Process <input type="checkbox"/>			

EXHIBIT 2-9: EROS DATA CENTER ORDER FORM



*Refer to Minimum Teleprocessing Communications System
 Program Number 5798-AA
 Program Description/Operations Manual

storage and retrieval system, to manage film annotation information by storing the information in a computerized data base, and to service inquiries against the data base [9]. The NASIS scheme (refer to Exhibit 1-6) is being evaluated for use here.

2.2.3.4.7.1 Data Base Structure

The data base structure employs block, strip, and scene accessions. An accession is defined as a collection of photographs including one or more spectral bands per image area that provide complete areal coverage. A block accession is a unit of aerial photography represented as a photo mosaic on a single microfilm frame as currently practiced by the USGS Mapping Project. A strip accession is made up of one or more frames that provide continuous areal coverage beneath a straight flight line segment. A typical example is the high altitude aircraft photography of NASA-MSC in support of the Apollo and Gemini projects. A scene accession is a single image of photography perhaps with multiple spectral bands such as the ERTS imagery. Each accession is uniquely identified with four corner coordinates which define the areal coverage included with the image boundaries. These coordinates are in units of degrees and minutes (to tenths of minutes) of latitude and longitude.

2.2.3.4.7.2 Data Management Subsystems

One of the most important subsystems in the data management system is the Data Inquiry Subsystem. This subsystem provides the capability to search the Main Image File for those accessions having specified attributes. The main program utilized here is the Minimum Teleprocessing Control System (MTCS) purchased from IBM. MTCS supports all terminal interfacing and all file input-output requests. The actual search programs are referred to as transaction processing programs (TPP). Exhibit 2-10 illustrates the Data Inquiry Subsystem.

The primary TPP utilizes an index file in searching the data base and leaves the identification keys for those accessions meeting search criteria in a common core area referred to as a Terminals Associated Storage (TAS). The geographic coordinates subroutine searches the permanent index file for photo accessions which fall in the specified geographic area. This area is determined by a polygon defined by at most 8 points. The output from the program is a count of the number of photo accessions and the file index numbers for these photos. Although the search index is based on geographic (latitude and longitude) coordinates, a conversion subroutine for Universal Transverse Mercator (UTM) coordinates is available.

The secondary TPP assumes that a primary TPP and/or a secondary TPP has been previously executed. Only those accessions are searched whose keys are contained in TAS and the number meeting the specified attributes is reported. Identification keys for only those accessions

meeting the test are left in TAS. Subroutine "Scale" examines photo accessions to meet a ground scale criteria as requested by the user. Subroutine "Date" examines photo accessions to meet a date-take criterion. The input from the terminal operator is a definition of the desired date or dates to be selected. Subroutine "Stereo" examines photo accessions to meet a stereo overlap percentage criteria. The input from the terminal operator defines the desired stereo overlap percentage. Subroutine IOCC examines photo accessions to meet image quality and cloud cover criteria. The input from the terminal is a two digit code representing the minimum image quality and cloud cover acceptable. Subroutine "Film" examines photo accessions to meet a type of film criterion. The input from the terminal operator is a list of up to nine acceptable film types.

2.2.3.4.8 NASA Data Management System

Mr. Robert Bell of NASA H.Q. chaired a working group which created a plan for a multi-agency data dissemination network for earth resources survey data [10]. This plan led to a study by an interagency working group to determine the users' requirements for a data retrieval system (DRS) for the Earth Resources Survey (ERS) program. The DRS is to serve as the heart of the Integrated Network Data Handling System (Exhibit 2-11) previously derived and agreed to by the working group participants." Two similar data retrieval systems developed by NASA were under consideration. One is the National Aerospace Safety Information System (NASIS) which was developed for the Aerospace Safety Research and Data Institute at the Lewis Research Center. The other, RECON, was developed to retrieve the NASA aerospace literature collection presently numbering some 800,000 documents. NASIS was selected and implemented by the Lewis Research Center. NASA has assumed the responsibility for the development of the system and for its operation for one year after the launch of ERTS-A. During this time the system is to be corrected and modified as may be indicated. NASA is proceeding under the assumption that some time during that year a decision is to be made as to which agency would be responsible for the continued operation after the initial year.

The data retrieval system is structured to manipulate the proposed data fields shown in Exhibit 2-12. The acquiring NASA center provides the primary data fields such as date, time, geographical coordinates, sensor, etc. (items 1-14, 16, 17, 18, 19 and 20 in Exhibit 2-12.) Inverted files permitting a rapid search of the data base using Boolean logic include geographic coordinates, scale, time, etc. (items 1-7, 10, 13, 14, 16 and 17 on Exhibit 2-12). Users provide descriptors pertinent to image content, comments (which would be attributed to an individual, organizational unit or terminal) and any reference to ground truth such as that obtained by means of the ERTS data collection system. User access to the system can be through remote terminals. Request specifications are reviewed by the Data System Manager, and used to update the description of the imagery.

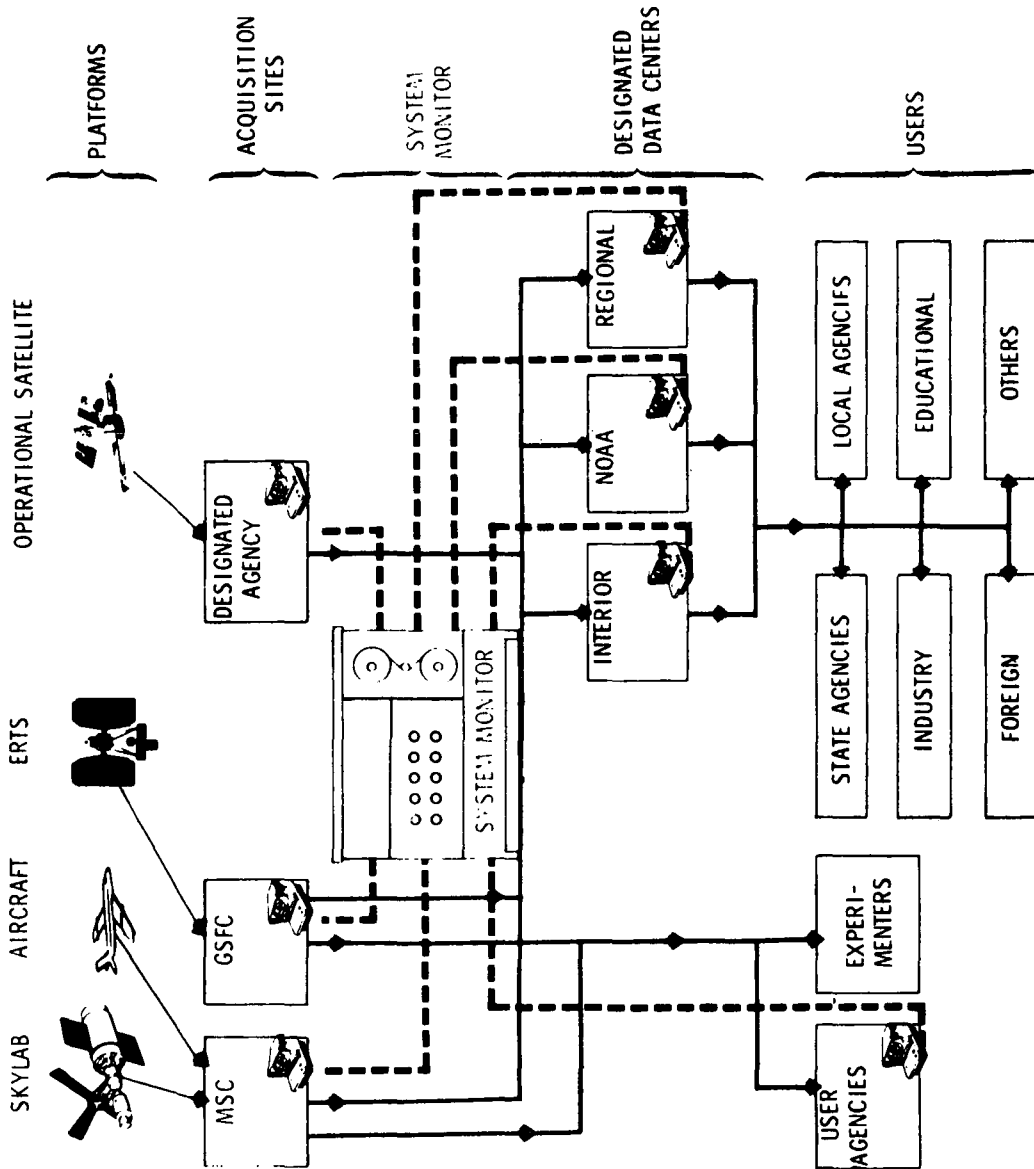


EXHIBIT 2-II: INTEGRATED DATA HANDLING NETWORK

1. GEOGRAPHICAL COORDINATES	13. QUALITY
2. DATE	14. SUN ANGLE
3. TIME GMT	15. DESCRIPTORS (CONTROLLED AND UNCONTROLLED)
4. SENSOR/CAMERA	16. MISSION/FLIGHT/ORBIT
5. FILM	17. SPECIAL PROCESSING
6. FILTER/SPECTRAL BAND	18. SENSOR PARAMETERS
7. SCALE	19. LOCATION OF DATA
8. ACCESSION NUMBER	20. SENSOR ATTITUDE
9. LOCAL ACCESSION NUMBER	21. GROUND TRUTH
10. PER CENT CLOUD COVER	22. DATE OF ENTRY INTO SYSTEM
11. ALTITUDE	23. DOCUMENTATION
12. PLATFORM	24. COMMENTS

In general the types of terminals that can be used to access the data must be compatible with a CC-70 communication controller, such as a teletype or an IBM model 2741. The terminals can be rented at prices ranging from \$100 to \$400 a month. The standard RECON terminal can be purchased for \$7000. NASA can assist the users in determining what terminals can be used and in providing training for using the system.

2.2.3.5 Interviews

The information contained in the directories, organization profiles and tableaus can be summarized in part from publications [e.g., 3,4,5], but much of the details necessary for detailed system design must be obtained from interviews of source data agencies. The steps in planning an interview are:

- o Specifying the target sample
- o Selecting the sampling frame for the target sample
- o Developing a sampling mechanism
- o Developing a survey instrument: e.g., a questionnaire

The interview of agencies is mainly oriented toward questioning organizational department heads to learn how each department operates within the agency in producing and processing earth resources information.

Exhibit 2-13 is a questionnaire form used to interview the key staff of the Geological Survey of Alabama. The results of the interview are found in Appendix A-3. To elaborate on some of the items found on the form, cooperative agencies are those who have a formal or informal role in the information flow by providing, exchanging and receiving information concerning on-going projects.

Within the agency system services, mission, scope, and methodology define properties of the information space encompassed by the agency that are important features for linking information systems together. Other properties are described by agency documentation, the information system, and general data content.

Exhibit 2-14 is a questionnaire used by the Federal Advisory Commission on Water Data [5] to compile material pertaining to water data handling methods and associated computer applications. Appendix A-5 tabulates the results from the use of that questionnaire.

ORGANIZATION: (ADDRESS, TELEPHONE, HEAD)

PERSON (S) INTERVIEWED	NAME	TITLE	ADDRESS	PHONE
------------------------	------	-------	---------	-------

COOPERATING AGENCIES: (SUB AGENCIES, RELATED AGENCIES)

GEOPOLITICAL DOMAIN:

ORGANIZATION:

ORGANIZATIONAL STRUCTURE (STAFF)

DESCRIPTION OF SYSTEM SERVICE (MISSION, SCOPE, METHODOLOGY)

DOCUMENTATION DESCRIBING SYSTEM OR SERVICE (COPY: TITLE, AVAILABILITY)

INFORMATION SYSTEM (S)? (TITLE, FLOW CHART)

TYPES

LIBRARY

DATA BANK

PUBLICATIONS (SERIAL, NON-SERIAL)

SERVICES

NETWORK PARTICIPATION

INTERFACE CRITERIA: (CONNECTION, USER'S MANUAL (S))

INFORMATION MANAGER? (NAME, TITLE)

DESCRIPTION OF SYSTEM

GENERAL DATA CONTENT

EXHIBIT 2-13: AN INTERVIEW FORM FOR KEY
SOURCE CHARACTERIZATION

INPUT DATA

1. Are water data recorded on specific forms? If yes, furnish a copy of each form used. This applies to data collected at a field site, the results of the analyses in the laboratory, and results of office computations.
2. Are instruction manuals used to guide recording of water data? If yes, please furnish a copy of each manual.

COMMUNICATION, PROCESSING, STORAGE, AND RETRIEVAL

1. How are water data communicated from site or laboratory to a center where data are processed? (By hand, radio, mail, etc.) Is the processing center in a field office or central location? (Subdistrict, district, regional, project headquarters.)
2. How are water data communicated between processing and storage facilities? (Mail, computer, by hand, etc.) Is storage at the field office and/or central location?
3. Where data go directly from site to storage, indicate method of communication and where storage is located (refer to No. 1).
4. Are communicated water data reduced, synthesized, or analyzed prior to storage? If yes, give short description of methods used. Where processing is automated so indicate in the narrative; if manual, furnish copies of forms used in placing data in storage.
5. How are data made available to user (i.e., retrieved from machine storage, from manual files, from microform files)? (Computer, hand.)
6. What kind of computerized system do you have for handling water data?
 - a. Type of computer (IBM 360 model 40, B5500, CDC 3600, etc.).
 - b. Operating system (OS, TOS, DOS).
 - c. Memory size.
 - d. Storage devices.
 - e. Output devices.
 - f. Software (abstract; if the program title is sufficiently descriptive as to purpose of program no additional comment is necessary).
7. Are microforms used in handling water data? If yes, describe devices and formats used and furnish sample format where available.

OUTPUT RELATING SPECIFICALLY TO BASIC DATA RELEASES

1. How are water data released? (Publication, printout, hand tabulation, microform, other - specify.) Furnish a copy of each type of release.

EXHIBIT 2-14: QUESTIONS PERTAINING TO DATA HANDLING PRACTICES [5]

2.3 KEY SOURCES: EXISTING INFORMATION SYSTEMS

An examination of earth resources information leads to the observation that there are two major attributes to be considered. One concerns the characteristics of the information content acquired, processed and disseminated by each information system. These characteristics have been examined and categorized by the definition, classification and characterizing methods discussed previously. The other concerns the earth resources system (Exhibit 2-15) and the means by which the data and information are transferred between and among the information systems. One of the major concepts of ERISTAR is to provide a means for information transfer through a network which connects the existing information systems and their products to a common center. This leads to an information space concept, consisting of a plane of existing information systems and a plane of information descriptors.

2.3.1 Information Space Concept

The lower plane in Exhibit 2-16 represents the set of all existing major information systems with their concomitant satellites, research laboratories, mapping projects, and other data sources. The National Oceanographic and Atmospheric Administration's National Oceanographic Data Center (NODC), GULF Universities Research Consortium (GURC), and the Environmental Information Systems Office (EISO) are members of this set.

The upper plane represents the set of all major classes resulting from analysis of information sources. These are information function classes obtained through definition, classification and specification. The analysis leads to functional descriptors that include geographic areas, scientific disciplines, and information system types, which are the principal classes. The earth resources information function plane is derived inductively by mapping the descriptors associated with the existing systems of the lower plane into the upper plane, and then synthesizing the descriptors into three orthogonal, or typologically different class groups.

The discipline function of the systems primarily contains research results and information related to particular scientific disciplines or other relatively narrow fields of interest. An outline of the general discipline categories are illustrated in Exhibit 1-2. (and in more details in appendix A-3). Detailing the scientific disciplines for the needs of earth research information management entails construction of a comprehensive thesaurus over the spectrum of information terms within the earth sciences of meteorology, oceanography, geography, geology, botany, zoology and anthropology and their applied fields (e.g., forestry as related to botany, fisheries as related to zoology, etc.).

EXHIBIT 2-15: SOME KEY EXISTING AND EMERGING SOURCES OF EARTH RESOURCE DATA AND INFORMATION AT THE NATIONAL LEVEL

NOTE: BRACKETS INDICATE CO-LOCATED CENTERS.

ATMOSPHERIC

AERONOMY AND SPACE DATA CENTER	NOAA, BOULDER, COLORADO
UPPER ATMOSPHERE GEOPHYSICS WORLD DATA CENTER	
NATIONAL METEOROLOGICAL CENTER	NOAA, SUITLAND, MD.
NATIONAL WEATHER RECORDS CENTER	
NATIONAL CLIMATIC CENTER	NOAA, ASHEVILLE, NORTH CAROLINA
METEOROLOGY AND NUCLEAR RADIATION WORLD DATA CENTER	
NATIONAL AEROMETRIC DATA BANK	EPA, CINCINNATI, OHIO
STORAGE AND RETRIEVAL OF AIR QUALITY DATA - SAROAD	
AIR POLLUTION TECHNICAL INFORMATION CENTER	EPA, RALEIGH, N.C.

HYDROSPHERIC

NATIONAL OCEANOGRAPHIC DATA CENTER	NOAA, WASHINGTON, D. C.
WORLD DATA CENTER A - OCEANOGRAPHY	
MARINE INFORMATION BRANCH - NATIONAL OCEAN SURVEY (OCEANIC AND ATMOSPHERIC SCIENTIFIC INFORMATION SYSTEM - OASIS)	NOAA, ROCKVILLE, MD.
NATIONAL WATER DATA SYSTEM (NATIONAL WATER DATA EXCHANGE)	
WATER RESOURCES SCIENTIFIC INFORMATION CENTER	USGS, WASHINGTON, D. C.
SYSTEM FOR TECHNICAL DATA ON WATER QUALITY--STORET	EPA, ARLINGTON, VA.
SCIENTIFIC INFORMATION PROGRAM IN EUTROPHICATION	UNIV. OF WISCONSIN, MADISON
WORLD DATA CENTER A - GLACIOLOGY	USGS, TACOMA, WASHINGTON

LITHOSPHERIC

WORLD DATA CENTER - LONGITUDE AND LATITUDE	NAS/U. S. NAVY, WASHINGTON, D. C.
TOPOGRAPHIC DATA CENTER	CORPS OF ENGINEERS, WASHINGTON, D. C.
MAP INFORMATION OFFICE (NATIONAL CARTOGRAPHIC INFORMATION CENTER)	USGS, WASHINGTON, D. C.
(RESOURCE AND LAND INVENTORY - RALI)	USDI, WASHINGTON, D. C.
MINERAL RESOURCE EVALUATION	BUREAU OF MINES, USDI WASHINGTON, D. C.

EXHIBIT 2-15: (CONT'D)

NATIONAL EARTHQUAKE INFORMATION CENTER

NOAA, ROCKVILLE, MD.

SEISMOLOGICAL DATA CENTER
GEODETIC DATA CENTER

NOAA, ASHEVILLE, N.C.

GEOMAGNETIC DATA CENTER
WORLD DATA CENTER - GEOMAGNETISM

NOAA, ROCKVILLE, MD.

BIOSPHERIC

AGRICULTURAL SCIENCES INFORMATION NETWORK
(NATIONAL SOILS DATA BANK)

USDA, BELTSVILLE, MD.
USDA, WASHINGTON, D. C.

INFORMATION SERVICES

CENSUS BUREAU,
WASHINGTON, D. C.

INFORMATION SYSTEM AND DATA BANK

BUREAU OF LABOR
STATISTICS, WASHINGTON, D.C.

MULTI-SPHERIC

WORLD DATA CENTER - COORDINATION OFFICE

NAS, WASHINGTON, D. C.

NATIONAL ENVIRONMENTAL SATELLITE CENTER

NOAA, SUITLAND, MD.

(EROS DATA CENTER)

USDI, SIOUX FALLS, S. D.

EARTH RESOURCES RESEARCH DATA FACILITY

NASA, HOUSTON, TEXAS

ENVIRONMENTAL INFORMATION SYSTEM OFFICE

AEC, OAK RIDGE, TENN.

(ENVIRONMENTAL QUALITY INFORMATION AND PLANNING
SYSTEM)

CEQ, WASHINGTON, D. C.

CENTER FOR SHORT-LIVED PHENOMENA

SMITHSONIAN INSTITUTION,
WASHINGTON, D. C.

ENVIRONMENTAL DATA SERVICE
(ENVIRONMENTAL DATA INDEX - ENDEX)

NOAA, ROCKVILLE, MD.

Key to Abbreviations

NOAA - National Oceanic and Atmospheric Administration
EPA - Environmental Protection Agency
UNESCO - United Nations Educational, Scientific and Cultural Organization
USGS - United States Geological Survey
NAS - National Academy of Sciences
USDI - United States Department of the Interior
USDA - United States Department of Agriculture
NASA - National Aeronautics and Space Administration
AEC - Atomic Energy Commission
CEQ - Council for Environmental Quality

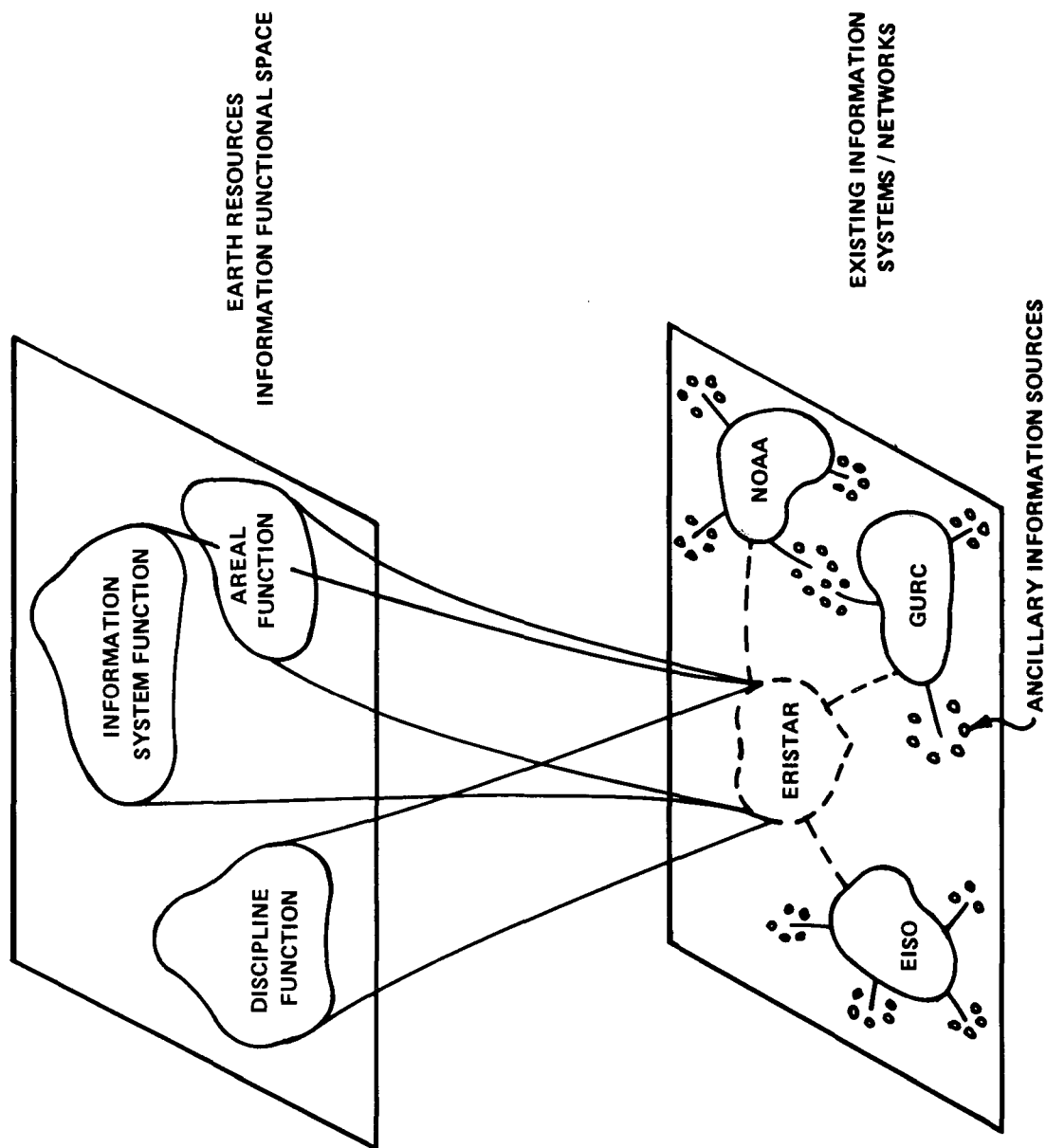


EXHIBIT 2-16: TOPOLOGICAL MODEL FOR ERISTAR INFORMATION SOURCES

In general, Information Analysis Centers (as defined in Section 2.2.2) can be categorized as a system type having a narrowly defined discipline orientation. An example of an existing system that falls in this category is the Geological Survey of Alabama (GSA) since their main interest is in the discipline of geology (Appendix A-3).

The areal function of information systems centers about its specific geographical domain. The system may be single or multiple discipline oriented but its outstanding characteristic is the primary applicability of its information content to a specific geographical area.

The geographical areas primarily encompassed by the source data and the user of an information system are classified by geopolitical domain, viz., international or a defined subset (e.g., Latin America), national, regional, state or province, and lower political subdivision. Other areal classification schemes include physiographic provinces, e.g., Atlantic Coastal Plain, Piedmont, Appalachian Valley and Ridge, Appalachian Plateau; or geomorphic classes such as deserts, mountains, intermontane valleys, etc. One will find similar area descriptors in many of the existing earth resources data bases. Furthermore, any areal classification should include data and information expressed in standard coordinate schemes, such as the Universal Transverse Mercator System. GURC adopted that approach in gathering data relative to the bays and estuaries in the Gulf of Mexico. Their development of a predictive management system, called "Information for Resources Management System" (INFORM), involves studies in the disciplines of biology, geology, geophysics, meteorology, pollution, acoustics, optics, and economics. [7].

Information system types include categories such as libraries and information abstracting services (Exhibit 2-6). This system type function combined with elements of the discipline function and the areal function determines the types of membership in the Earth Resources Information Function Plane for each information system.

Mapping of the orthogonal functions of the upper plane to the lower plane, leads to a concept for an earth resources information management network system (such as ERISTAR) which integrates all of the functional components. Since none of the existing information systems contains all of the necessary functions, the need for an ERISTAR system is reinforced.

It becomes apparent from examining Exhibit 2-16 that the proposed ERISTAR must be a network in order to avoid undue duplication and to make maximum usage of existing systems. The network connectives and decisions regarding their optimum specification must await trade-off studies. In any case, an information management system design must be responsive to and interact with the highest level existing information system for maximum efficiency.

2.4 CENTER OPERATION AND NETWORK FUNCTIONS

The network concept was developed in section 2.3 from consideration of earth resources data and information resident in information systems, and the need for ERISTAR to tap these data resources. The network concept and consideration of management functions are discussed in section 5.2. Section 2.4 emphasizes the factors to be considered in connecting the ERISTAR center to external data sources, and the data management functions with center.

2.4.1 Network Considerations

The concept of the earth resources information space has the important element of system connectives between an ERISTAR center and other information systems in a network configuration. The connectives may be one or more of the interfacing types illustrated in Exhibit 2-17. The specific interfacing between ERISTAR and an external system data base (or processing unit) can be specified at the time of ERISTAR implementation on the basis of nature and form of the source data, and the cost/benefit considerations of where the data should be in residence. By nature of the source data is meant the specific content, for example, document indices, bibliographic listings, numerical data, and the like. Form alludes to the definitions of Exhibit 2-5, in particular whether the data are digitized and computer compatible or not. Having a teletype terminal at the ERISTAR center may be the optimal interfacing to the RECON document system of NASA, whereas water resource data in the EPA STORET system that is specific to a local region may be partitioned from the national data base and maintained at the ERISTAR center.

An information management system dedicated to the principle of avoiding whenever possible the replication of files resident within other systems implies some rather difficult problems in system interfacing and data transmission. The U. S. Department of Interior "Resource and Land Information" Program [8] contains this principle as an integral concept which was expressed as a recommendation by the Water Resource Review Committee (Exhibit 1-9). Inherent in this design is the capability of the central processing center to respond to a user request by generating a code specifying the necessary data element types, their residence, search codes and sequences for each of several possible off-center residence files. Since each center will probably manage its information storage files with his own unique data management language, the interfacing mechanism must accomodate a variety of language and hardware coding characteristics among the interrogated centers. The CODASYL Data Base Task Group has addressed itself to this problem, and has recommended that each computer manufacturer provide a Data Description Language (DDL) which yields a schema, a machine independent description of the data base for system interfacing [15].

INTERFACING TYPES				
SOURCE	ERISTAR	EXAMPLES	DATA TRANSMITTED/RECEIVED	
COMPUTER	COMPUTER	BURC	DATA ELEMENTS	
COMPUTER	TERMINAL	RECON	SEARCH ELEMENTS/BIBLIOGRAPHIC DATA	
		EROS	SEARCH ELEMENTS/BIBLIOGRAPHIC DATA OR REMOTE SENSED IMAGERY SPECIFICATIONS	
		STATE/LOCAL FILE CREATION, UPDATE, ETC.	DATA ELEMENTS	
MAN TELEPHONE MAIL	MAN TELEPHONE MAIL	CURRENT AWARENESS INFORMATION	REQUEST SPECIFICATION/ INFORMATION	

EXHIBIT 2-17: ERISTAR CONNECTIVES

For data accessed frequently from a national-or international-level file, and for data originating and applied only on relatively restricted sub-national levels, the system cost/benefit evaluation may favor the creation and maintenance of data banks within the ERISTAR center. In contrast, data and information requested infrequently and for which the application can tolerate considerable delay in acquisition should not be transferred to on-center storage. Only its residence place and means of acquisition need be recorded. A large amount of earth research data and information fall into this category.

The ARPA Network study and augmentation group has begun implementation of a special computation software system (NLS) for their on-line system to connect users and centers within a national network [16]. This concept appears to be an expansion of the conventional institutional computing center into one having national scope and interconnected centers, with the goal of development of on-line computer aids for augmenting the performance of individuals and teams engaged in intellectual work. The ERISTAR network could be designed along a similar plan, using the ARPA software and interfacing capabilities of their Network Information Center in application to the earth resources information management problem.

2.4.2 Types of Data and Information Files

The nature of earth resources sources data and its organization has been discussed in terms of definition, classification, and specification of data content, forms of data organization, and systems into which the data are contained. The discussion covered means of interfacing system networks inasmuch as this is an important concept of the ERISTAR design. Additional consideration should be given to data management in terms of types of data file sets and data organizational methods utilized in a data management system. The purview of sources concern within the ERISTAR information management system interfaces with processing concern at data management, especially that part responsible for managing records and files of source data. (Exhibit 2-18).

Meadow [11] describes four main types of files:

- o Document Files: the documents, in the form of books, journals, articles, and computer-readable text. Microform files, photographic imagery, and satellite digital images are components of this set.
- o Data Files: Those containing alphanumerical data, commonly called "raw data". Normally included are variables with their corresponding scales and values.

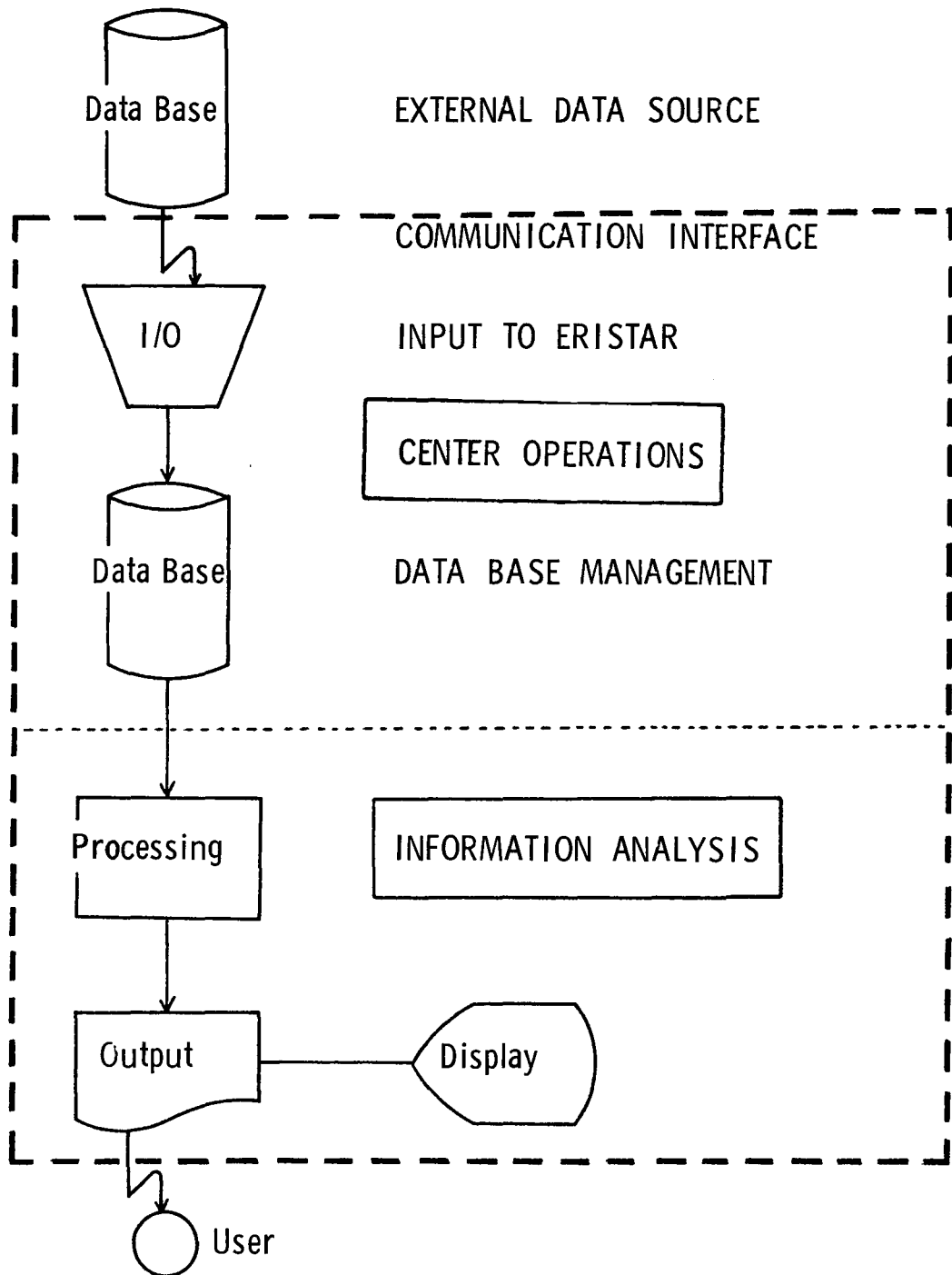


EXHIBIT 2-18: ERISTAR CENTER OPERATIONS RELATIVE TO EXTERNAL DATA SOURCES

- o Index Record Files: sets of index records, each record being the index of a single document.
- o Structure Files: files produced as a result of organizing record sets into various file structures, which include index keys to the data elements. Structure files differ from index record files only in regard to their referents, the index record file always has the documents as external referents.

2.4.3 Data Organizational Methods

The methods of organizing records in a file determine the data structure. The data base management system deals with records in a file. The records contain information, called elementary data elements which are the objects of information processing [12]. There are basically three data organizational methods: sequential, random and list.

In the sequential organization the records are stored according to a specified sequence. A telephone directory is an example of sequential file on a direct access media. The record is the name, address, and telephone number, the latter normally being the data element retrieved.

The advantages of the sequential file are the rapid access per relationship during retrieval. Where the file is stored on continuous media (e.g., tape), it may be necessary to search almost the entire file to retrieve the appropriate data element. With direct access media, such as disk or drum, more efficient searching techniques can be used. The analog of the telephone directory is somewhat appropriate wherein searching can be optimized by knowledge of the alphabetical order, and the file entered near to the record sought. Thumb indexing in a language dictionary is a similar search-optimizing device which can be used in file searches.

Other disadvantages of sequential files are in updating blocked records and inserting new records. Often the entire file must be rewritten after updating or correction.

The random data organization contains records which are stored and retrieved on the basis of a predictable relationship between the record key and the direct address of the location where the record is stored. Various methods are used to effect the relationship between the key and the record. Included are a direct address, known and utilized directly by the programmer, a dictionary look-up, a structure file containing both the record's key and its direct address in storage, and calculation, whereby the key is converted into a direct address by a calculation algorithm.

The advantages of random organization are that any record can be retrieved by a single access, and individual records can be stored, retrieved, and updated without affecting other records in the file. The major disadvantages are the unsuitability for rapidly accessing a number of records, and the unwieldiness of large dictionaries

List organization makes use of pointers, which are logical file cross indexing connectives used to locate a record. The basic concept of a list structure is that it utilizes points to separate the logical organization of the file from the physical organization.

There are three main types of list structures: simple list, inverted list, and ring. The simple list has pointers from record to record that are not necessarily entered sequentially. A record may be a member of several lists, which are strings of pointers through the records. This enhances retrieval of appropriate records and sequences of records. However, where records are part of several lists updating becomes difficult, and where lists are long retrieval time is extensive. If the list length is restricted the effect is to create sublists, each of which has its own starting point. The index of starting points may become overly large and difficult to maintain with many sublists to reference.

Inverted list structures make every data element available as a key, and each key appears in the index to the file. This is a type of permuted index, the entry to the file being possible at each data element type into which the file is inverted. Such an organization requires a dictionary of all data element types in the system containing the addresses of all locations where the types occur. Inverted files allow access to all data with equal ease, and are more particularly suited to decision making and planning functions than to specific processing functions. File maintenance is more difficult with inverted files because the dictionaries must be altered with each modification of file content.

Ring structures are extensions of inverted list structures in which the pointer in the last record in the list refers back to the first record of the ring, making it possible within the list to find the next record, previous record, or starting record of the ring. Considerable variety is possible within this type of structuring, which make the ring a versatile type of file organization. It facilitates retrieval and processing of all records in a selected ring with the additional ability to retrieve and process all records logically related within nested hierarchies. The hierarchial ring structure takes advantage of the rapid processing of logically related data elements in the ring, while having referents to related data accessible within the file. This avoids the necessity of the processing path returning to the retrieval program specification and back to the related data. Also, the rings are easier for record insertion and removal than are other list structures. These advantages are gained at the cost of space for the pointers in the file, although pointers reduce the number of keys to be maintained in large dictionaries.

At the time this report was written the principal method of storing large data files continues to be on magnetic tape, largely because of cost and the high effective data transfer rate of magnetic tape read and write devices. This effectively restricts file organization to sequential structures within this milieu. However, large fast direct access discs and drums are rapidly replacing magnetic tape. In a few years magnetic tape may be utilized only for seldom used, archival or secondary information storage.

2.4.4 Data Base Management Systems

Generalized data base management systems are discussed in several reports of the CODASYL study group [13, 14] and detailed analysis was made of nine such systems. There are others in existence not covered by this report, and yet others in the process of development. However, it is the intent of this survey to outline the major features of the systems rather than to make detailed comparisons among them.

The more elementary systems search a sequential file having simple record structures and provide only rudimentary report formatting facilities. More elaborate systems handle some of the more complex file organization structures discussed above, and provide for many additional file management functions and features.

2.4.4.1 Features of Generalized Data Base Management

The capabilities of a data base management system (DBMS) can be expressed in terms of the major functions to be performed by the systems. These essential functions are defined by the CODASYL group as:

- o Data Structure Capability: the logical structure of the data excluding details of storage techniques discussed previously (section 2.4.4) under Data Organizational Methods. Data structure levels include the concepts of data element, group, group relation, record, file and data base. Data structure is commonly referred to as a schema.
- o Data Definition: the language or tabular formats used to define the schema representable within the systems' capability to handle data structures.
- o Interrogation: the process of selecting and extracting some elements of the data base for transfer, processing and display. The interrogation function is twofold, one defining how the elements are to be selected, and the other how computation, sorting and formatting may be performed on the selected part. In the DBMS language, the processing of an interrogation is self contained, and the user need not detail the sequence of steps in the process.

- o Update: the process of changing the value content of data elements in the data base. Like interrogation, the DBMS language facility should provide a built-in processing facility for updating.
- o Creation: the process of creating a file provided a set of records on which to perform this function. Data base creation is one of the most important functions for the data administration.
- o Programmer Facilities: functions upon which a programming user may call when writing a program in a host language (in contrast to DBMS language). Some important functions are initiating data transfer between stored data base and high speed memory, and issuing file control statements.
- o Data Administrator Functions: in connection with a generalized data base management system, there are prescribed functions to be performed by the data administrator, the individual responsible for a data base. The functions include monitoring system operation, preservation of system integrity and security, and providing for structuring the data base to accommodate new record types or new items.
- o Storage Structure: each level of the data structure has a storage structure. The file level storage structure defines how records are stored in physical blocks to form the stored representation of the file. Item level storage structure usually reflects the storage modes of the machine although data base management systems exercise different levels of control over data structure in terms of mapping of data elements into storage structure formats.
- o Operational Environment: consists of the hardware and software environment provided by the operating system, and is relevant to the interfacing of the DBMS with other software components.

The feature of generalized data base management systems that differentiates them most importantly is the difference between the host language capabilities and the self-contained language capabilities. The host language capabilities are those embedded in a language such as COBAL or PL/1, and are in essence tools for the applications programmer. The self-contained capabilities are embedded in the DBMS, and usually have no language connection with any procedural language. The 1971 CODASYL report [14] makes extensive comparisons of these properties in the systems studied.

2.4.5 Implications

The significance of this discussion is that the center operations must consider the earth resources data, whether in residence or tapped through network interfacing with other information analysis centers,

in terms of the types of files, data organizational methods, and the methodology of managing the data bases resident within the ERISTAR center. The data bases may be a permanent feature of the center, or may be temporary files.

Managing data bases may be effected through programming effort of the ERISTAR center staff, utilizing high level languages which have many of the necessary features built in, such as COBAL or PL/I. Alternatively, a generalized Data Base Management System may be created as an ERISTAR project, or one already in existence may be adapted to the ERISTAR needs. This is a matter for future consideration in the detailed design of the ERISTAR system.

2.5 SUMMARY

In this chapter some preliminary features of the earth resources data and information were discussed in terms of the nature and characterization of the source data, and how the characterization should be organized so that it can be accessed, processed and disseminated. Characterization was discussed on two levels, microspecification and macrospecification. Microspecification incorporates the concept of data element description and classification, and this was displayed in terms of general discipline or subject area descriptors. It should be stressed that all source data, whether generated by satellites or by more traditional information generators (such as the Geological Survey of Alabama) must be microspecified. An example, though still on too general a level, can be formed in the Data Content specification of the Geological Survey of Alabama (Appendix A-3). This is an information analysis and indexing procedure which must be performed by the information management center on all data collections - document files, data files, index files and the like.

Macrospecification alludes to description of information content of large information elements - the organizations and existing information analysis centers. The dictionary, profile and tableau are ways of documenting macrospecifications. But it should be eminently clear that macrospecification is a roadsign to microspecification, and the earth resources data and information collection must have their own microspecification for the data to be useful for processing into the user format.

Organization of the micro and macro specified data at the earth resources information management center, such as ERISTAR, entails organizing the data into document files, data files, index files and structure files by one or more of the methods discussed in section 2.4.3. This center function is the data base management and its associated activities. It is an integral and necessary function that provides the earth resources data in an organized and specified fashion to the processing function.

Only when the source data and information are identified, categorized, specified and organized can the processing function perform the necessary steps of data transfer and transformation into the user product; provided, of course, that the user product is equally well specified. The discussion of Chapter 3 details many of the center operations, including source data specification and some general processing functions.

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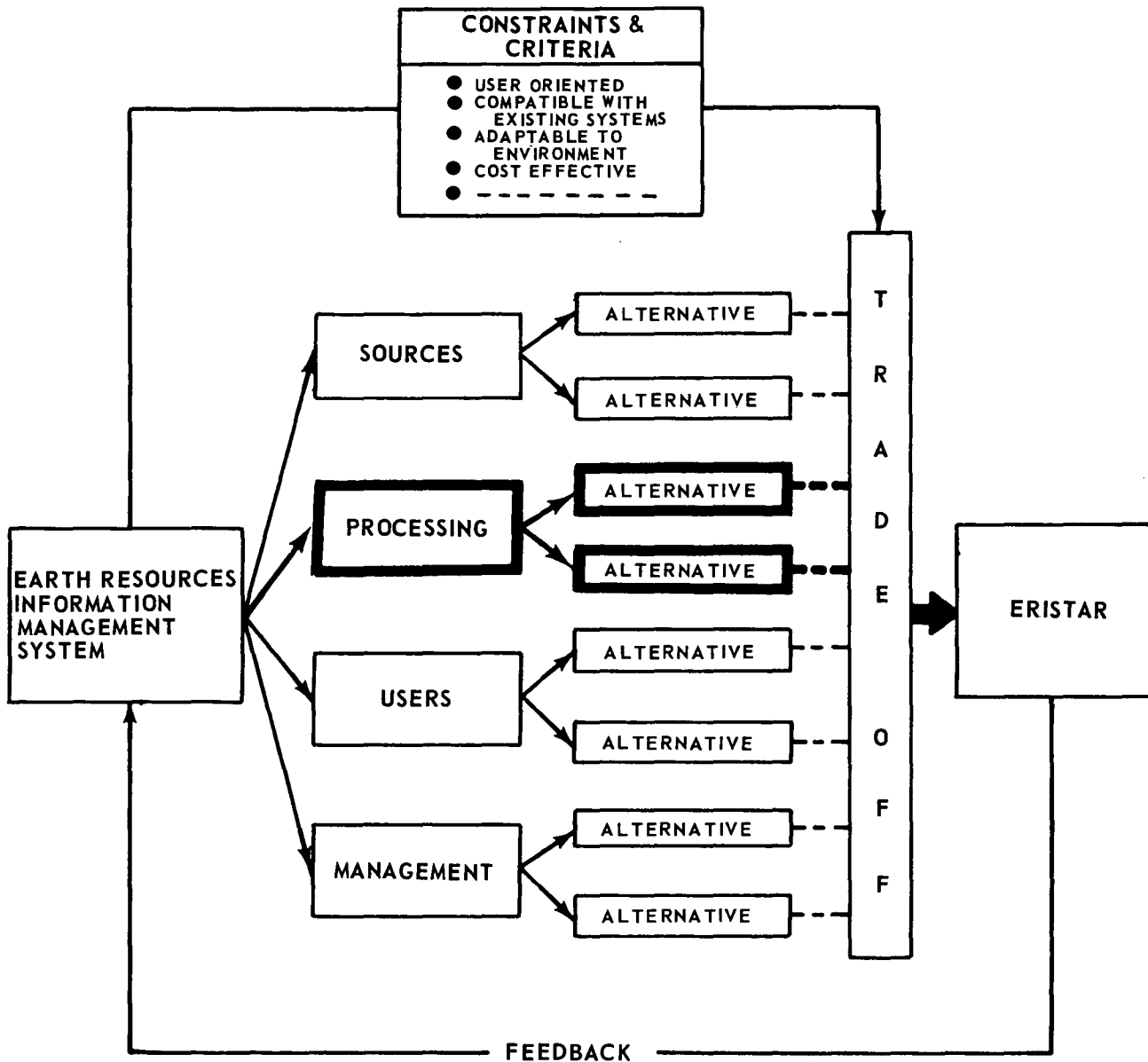
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3. PROCESSING



3.1 INTRODUCTION

This chapter presents the conceptual design of the processing subsystem of ERISTAR. As shown in Exhibit 3-1, the processing subsystem is one of four operational subsystems in the ERISTAR system. This chapter is developed in the framework of the systems approach as illustrated in Exhibit 3-2, which shows the progress of the systems approach with respect to the processing subsystem.

3.1.1 Objective

The processing subsystem has as its objective the performing of functions in such a way that the data and information acquired from pertinent sources are transformed into the information needed by the users. This objective is somewhat analogous to that of a processing industry which, for example, transforms pulpwood from certain types of trees into paper products. The processing functions for an earth resources information management system, like those for a typical processing industry, are numerous and varied, and are performed by both men and machines.

3.1.2 Background

This section provides some of the background for the problem of designing the processing subsystem of an earth resources information management system. Current and planned earth resources information processing activities form a reservoir from which a processing subsystem could be structured. The greatest need is to provide some mechanism for coalescing these activities into a united functional system. These current and planned activities, as well as the needs for new activities, are discussed in this section.

3.1.2.1 Current Earth Resources Information Processing

The totality of existing systems for earth resources information processing is too vast to describe here. Indeed, one of the research activities that could logically follow the present project would be to develop an encyclopedia of existing earth resources information systems. The purpose of this section is to describe the processing aspects of some of these systems and to outline some general techniques for cataloging present processing activities.

There are numerous ways in which current information processing activities can be cataloged. One scheme would be to categorize them by the level of management: national, regional, state, district, and local. Another method would be to classify them by type of original data source: satellite, aircraft, or ground. A third basis for classification might be disciplinary, with such divisions as geological, hydrological, and oceanological. Yet another scheme might organize processing activity according to its primary capabilities: image processing, digital processing, and archival storage, to mention a few.

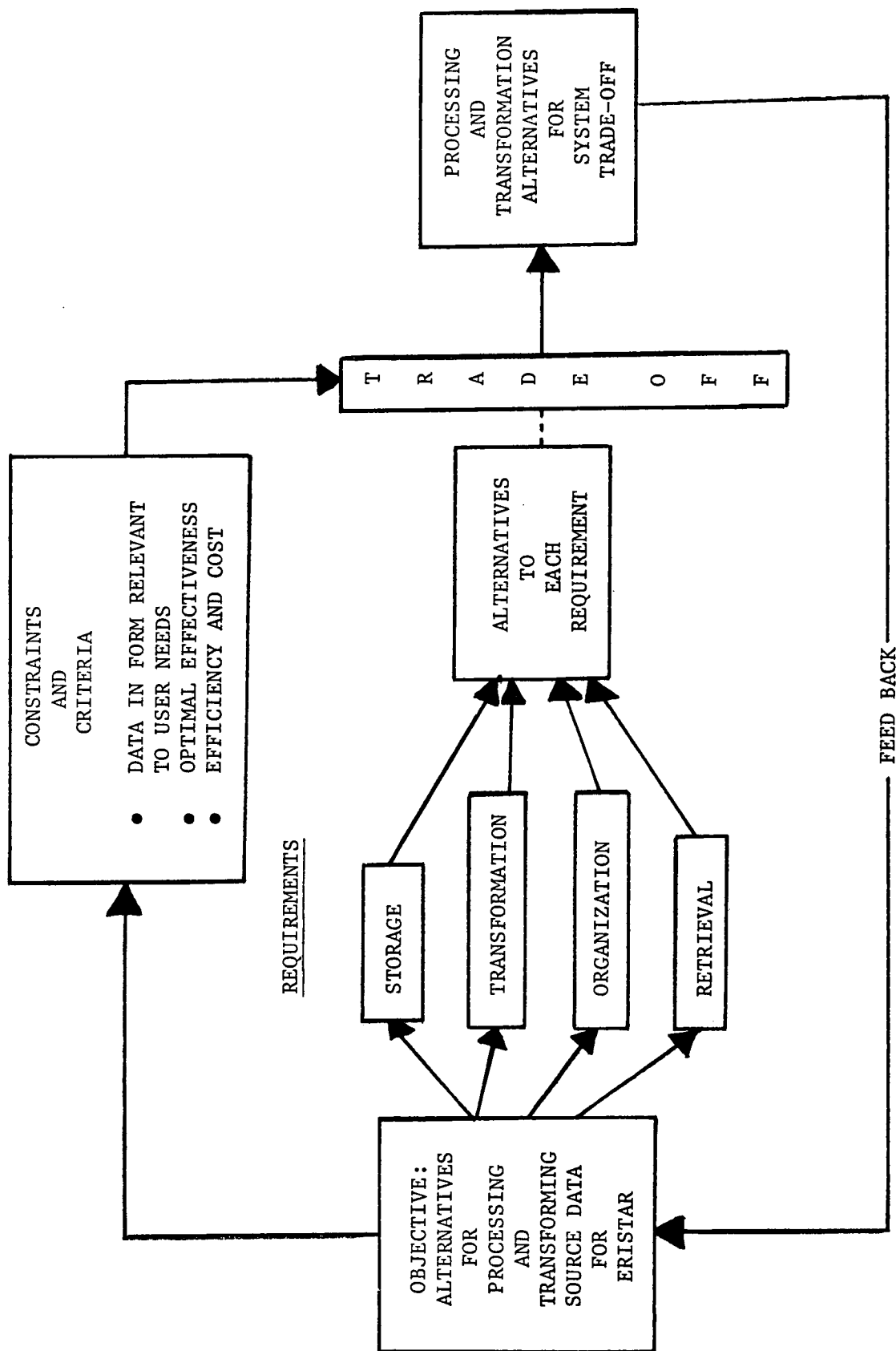


EXHIBIT 3-2: PROCESSING SUBSYSTEM DIAGRAM

Perhaps the most convenient procedure for cataloging earth resources processing activities would be to combine several of the more important of these mechanisms into a multi-dimensional classification scheme. For example, consider a three-dimensional scheme with the dimensions: (1) management level, (2) information source, and (3) discipline. Using this classification scheme to guide the analysis of current processing capability, it becomes clear that most of the cells in a multi-dimensional matrix are occupied with some degree of activity. A discussion of a few of these activities will perhaps aid in filling out a small portion of this matrix.

Consider the earth resources information processing activity of the NASA Data Processing Facility (NDPF) at the Goddard Space Flight Center in connection with the (ERTS) Earth Resources Technology Satellite [1]. This facility is discussed in detail in Appendix B. As suggested earlier, this activity would occupy an entire row in a three-dimensional matrix of current activities. This row would lie at the national level and satellite source, and span all disciplines.

Another earth resources processing activity within NASA is the Earth Resources Research Data Facility at the Manned Spacecraft Center (MSC). This facility is organized for the collection, processing, and dissemination of earth resources data generated by NASA Earth Resources Programs, principally the aircraft program operated from MSC. Types of information available include the following: space photographs, photographs, infrared and microwave data from aircraft sources, results of technical investigations, symposia proceedings, photogrammetric studies, journal articles, and bibliographies. These data and information cover the disciplinary areas of agriculture/forestry, oceanography, hydrology, geology, and geography. Information is disseminated to government agencies, educational institutions, industry, commercial firms, and foreign governments. Its principal processing activities include image processing and physical storage of hardcopy.

On a regional level, the Environmental Information Systems Office (EISO) of the Oak Ridge National Laboratories is an example of current earth resources processing capability [39]. EISO is connected with some 200 environmental information centers around the nation, including some 15 in the Environmental Protection agency. Data bases are largely maintained in computer storage. When a user addresses an inquiry, an information specialist interprets the question and accesses the data base. He also performs any detailed analysis required to satisfy the users' needs.

On a state level, the State Geological Survey of Alabama is an example of a current earth resources processing activity [16]. Its processing activities include the preparation of reports, imagery, and maps which reflect some analysis and interpretation of geological data acquired largely from ground sources in the state of Alabama. It stores and disseminates this information to users.

As an example of a local earth resources processing activity, consider the Regional Information System for Environmental Management (RISEM) in San Diego, California [2]. One of the functional components of RISEM is the Data Management System (DMS), which is mainly concerned with file management. It is capable of providing statistics, geocoding, and graphics. It provides interpretation of these outputs to satisfy specific user inquiries.

Several other earth resources-related information processing systems do exist. Many of them have analytical capabilities in addition to the storage and retrieval functions. A brief list of some of them is given below.

- o United States Geological Survey (USGS)
aerial photographs, catalogs, browse files
- o Jet Propulsion Laboratories (JPL)
image processing, data processing, storage (archives of data)
- o NASA Aerospace Safety Information System (NASIS), Lewis Research Center
interactive search and alphanumeric display capability, dial-up capability, geographic search and terminal on-line capability, and is expandable
- o Earth Resources Observation System (EROS), United States Department of Interior, Sioux Falls, South Dakota
satellite and aircraft imagery, USGS photographs, computer tapes
- o National Space Science Data Center (NSSDC), Goddard Space Flight Center
archives of space data
- o Earth Resources Image Processing System (ERIPS), Manned Spacecraft Center
aircraft imagery, processing (scaling, enhancing, mosaicking, contouring, magnification, integration, convolution, multi-spectral analysis, image correlation, color enhancement, noise removal, smear removal, area identification, Fourier transforming, image registration)
- o National Oceanic and Atmospheric Administration (NOAA), United States Department of Commerce
- o Environmental Science Services Administration (ESSA), United States Department of Commerce
- o National Oceanic Data Center
- o National Climatic Center
- o National Geophysical Data Center and Aeronomy and Space Data Center
- o Environmental Science Information Center.

A more detailed description of these centers is also available [10].

The earth resources information processing activities described above are only a small sample of perhaps hundreds of such activities ongoing in federal, regional, state, local and private agencies throughout the United States. No doubt, most of these activities are confined to

specific disciplinary areas. But the current processing capability is both vast and highly diffused. Any system designed to serve as an earth resources information system should provide for tapping this enormous latent capability.

3.1.2.2 Planned Earth Resources Information Processing

In addition to the enormous reservoir of current activity in earth resources information processing, there are several planned programs as well. An example of such a planned activity is the Resource and Land Information (RALI) Program proposed by the Department of the Interior [3]. As conceived at present, this program would be established at the national level by fiscal year 1973. The implementation of the total system would stretch into the 1980's. There would be three levels of contact: (1) national, (2) regional, and (3) state. The focal point for information storage and analytical expertise would be at the regional level, while state centers would largely provide a reference service. Depending on the user's needs, his requirements would be satisfied by raw, interpreted or derivative data, analytical predictions, or by analyses of alternative policies and their impacts. The data and information would be provided as tabular or point data, maps, reports, and computer tapes.

Several states are presently participating in the ERTS programs, with intentions to establish some sort of earth resources information management system. In most cases, plans have not progressed to the point that those have for the RALI program.

3.1.2.3 Needs for Earth Resources Information Processing

Despite the numerous on-going activities and the planned RALI program, there remains an acute need for earth resources information processing capabilities. The greatest need is for a comprehensive system to weld together the capability that already exists. Beyond that, there are other needs that could be addressed by establishing a processing function within an earth resources information system. Some of these are as follows:

- o More national coverage at the necessary degree of detail for most kinds of analysis, especially in the area of land use maps.
- o More consistency of format, quality, standards, and scales between and within various categories of data, so that there can be more interdisciplinary problem-solving and sharing of data
- o Improved cataloging of existing data bases
- o Improved coordination of ongoing and planned earth resources information processing efforts
- o More detailed presentation of data and information for specialized users, and better interpretation of data for non-technical users
- o Less duplication of data storage

- o Elimination of conflicting and non-objective data in repositories
- o Better coordination of diverse data sources in preparing output information
- o Improved research and development activities with imagery processing and data reduction techniques, microform development and modeling techniques
- o Greater hardware compatibility
- o More adaptable software
- o Improved display modes.

Hence, the design of an earth resources information management system should make maximum utilization of existing processing capability and at the same time provide for the additional capability to satisfy the many needs that are readily evident. This chapter describes the evolution of the conceptual design of the processing subsystem of an earth resources information management system.

3.1.2.4 Overview of Chapter 3

The objective of the processing subsystem and some of the background of the problem have already been stated in the earlier sections of this chapter. The remaining portions of the chapter are devoted to describing the evolution of the conceptual design of the processing subsystem. The discussion is presented in the framework of the systems approach, as illustrated in Exhibit 3-2.

Having stated the objective of the processing subsystem, the next step in the systems approach is the definition of the subsystem requirements and subtasks. This process is described in section 3.2. As part of the analysis phase, and prior to delineating a set of alternative approaches, it is necessary to set forth the constraints and criteria, the controls, that the subsystem design must satisfy. This is treated in section 3.3. In delineating the alternative approaches, it was necessary to deviate somewhat from the standard systems format and describe alternative approaches to the total earth resources information management system. This came about due to the fact that the processing function interfaces so substantially with those of sources, users, and system management. Section 3.4 treats five total system approaches. Section 3.5 presents the trade-off methodology followed in proceeding from five approaches to a unified, time-phased implementation scheme for the total system. Finally, section 3.6 elicits the implications for the processing subsystem design. The final plan for the ERISTAR processing subsystem will be discussed in detail in Chapter 6, section 6.2.3.2.

In order to provide a background for examining alternative approaches, it is necessary to give detailed attention to certain aspects of the processing problem. Appendix B presents the results of several such detailed analyses.

3.2 REQUIREMENTS AND SUBTASKS

As diagrammed in the Preface of this report, the systems approach proceeds from the statement of the system objective to defining the requirements necessary to fulfill that objective. The processing subsystem objective has been stated in section 3.1.1. This section describes the requirements for the processing subsystem of ERISTAR. It further describes the refinement of the subsystem requirements into subtasks. Before embarking on a discussion of the subsystem requirements and subtasks, it might be instructive to define these two terms.

As discussed in the Preface, a "requirement" is a major function that the subsystem must perform in order to accomplish its objective. For example, the processing subsystem of ERISTAR might have the requirement of the storage of data and information. A "subtask" is a detailed activity that the subsystem carries on as part of one of its major functions or requirements. For example, as part of the storage requirement, the processing subsystem might have to provide for (1) magnetic storage for machine-readable data and (2) shelf storage of printed documents. Hence, a subtask is a subset of a requirement.

There are four requirements for the processing subsystem: (1) storage (2) transformation (3) organization and (4) retrieval. The relationships among these requirements relative to the sources and users are shown in Exhibit 3-3. This section describes these four requirements and their attendant subtasks.

3.2.1 Organization of Information

The information and information products acquired by the system must be placed in a logical organizational structure for proper and efficient storage and retrieval. Organization of information is one of man's most important activities. Consider the significance of Mendeleev's Periodic Table, or, the elements of Linnaeus' classification of living things as major scientific works. The storage requirement discussed below in section 3.2.2 is designed to deal with the physical access and handling of information, and so is the retrieval requirement discussed below in 3.2.3, to some extent. The organization requirement must also be present so that the system can specify the existence of desired information, identify all of the necessary pieces of information needed for any specific user, and determine the location of where the information is stored.

The system, as it acquires new information sources and products, must first analyze these sources and products to determine precisely what they are. Secondly, the system must see where in the overall information organization or framework the items belong. An efficient file structure is thus implied, so that the information product items may be stored properly for easy retrieval. Indexes and directories to the files are also implied.

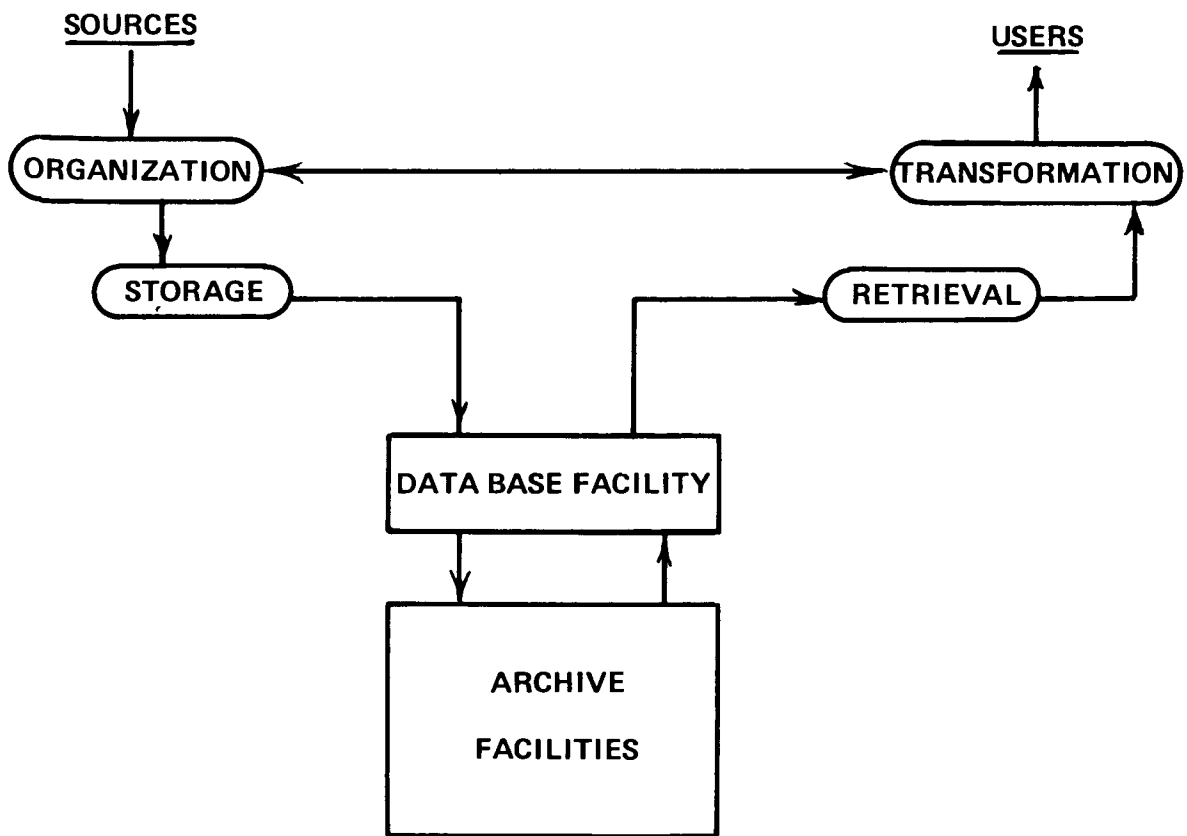


EXHIBIT 3-3: DIAGRAM OF PRIMARY DATA AND INFORMATION FLOWS AMONG PROCESSING FUNCTIONS AND FACILITIES

3.2.1.1 Content Analysis

Each piece of information must be analyzed to see what it is and how it fits within the general earth resources framework. The object is to determine what the information content is, so that it can be related to the various user queries for information. For example, a user might be interested in seeing recent aerial photos of northern Arizona at night in order to analyze the effects of man's existence on the ecology of the region. We must know which pieces of information are recent aerial photos of northern Arizona taken at night. Thus, we see that the information must be analyzed along several dimensions, or facets. A piece of data is "located" within the multi-coordinated information space by specifying where the data lies relative to each facet or coordinate. Some of the facets considered by the task groups, and also discussed above in Chapter 2, for an ERISTAR information system are:

- o Form
 - is the data a text or document, imagery, physical samples, or raw data
- o Resource Type
 - to what type of resource (general, land use, petroleum, air pollution, etc.) is the data or document related
- o Application
 - anticipated data uses or actual study applications, such as mapping, crop inventories, or land use policy
- o Location of Area Covered
 - the area under study in the data or document, such as northern Arizona, the temperate zones, or the Equator
- o Time
 - the time the data was collected or the study was published
- o Originator
 - the author, publisher, funding agency, or principal investigator behind the data collection or study
- o Storage Location
 - where the items are stored

- o Storage Form
 - the means of storage (punched cards, magnetic tape, microform, or hardcopy text)
- o Subject Disciplines
 - the subjects covered by a document or data library, such as chemistry, hydrology, or biophysics
- o Descriptive cataloging
 - the author, title, publisher, date of publication, and other bibliographic data concerning documents
- o Methods
 - the methods used in a study to collect or analyze the data.

Each piece of information must be analyzed along each of the appropriate major facets. This is quite analogous to the cataloging of books in a library. Each book is analyzed to determine its author(s), title, and the relevant subjects to which it pertains. As an example, consider the Library of Congress which analyzes its acquisitions, which include most of the documents published in the United States, and determines the subject content of each document [4]. Next, of course, comes the process of classification or indexing of the information.

3.2.1.2 Classification or Indexing of Information

Once it is determined that a piece of data is at a specific point in the multi-faceted information space discussed above, it is imperative that it be classified and cataloged as such, along with the other data pieces at that specific point. That is to say, we must assign to that data a heading, be it a name or a number, that tells the system what the content analysis has revealed about the piece of data. This is analogous to the Library of Congress which uses a set list of subject headings to denote the contents of the data under analysis. For example, if a document is about legislation related to libraries, it belongs under the subject heading "Library Legislation." This heading is the name of a concept, incorporating several related ideas that might have different names. Here we see grouped together such ideas as certification of librarians, library law, public institutions and the law, and libraries and the state.

The difficulty is in achieving uniformity, both among all of the information and among the user query interfaces. For example, a user may be concerned with "rainfall", while the data of interest is listed under "precipitation." Hence, we need names for the general concepts involved with each possible point along each facet as well as thesauri or links between titles of concepts so that one can refer to the desired concept with all of its names.

Moreover, the classification scheme may provide links to the physical location of the information. Libraries use Library of Congress and Dewey Decimal Classification schemes to depict the shelf location of the various books and other documentation stored. In our "Library Legislation" example, the subject heading is accompanied by a Library of Congress shelf number, Z677. This number denotes the section of the shelf storage of the library where books on the topic in question can be located.

The National Library of Medicine [4] produces a list of subject headings for the field of medicine and uses it to product an index to the documents related to medicine. This index is called Index Medicus. Moreover, there is an abridged version, called, appropriately enough, the Abridged Index Medicus. Some attempts have been made (Medlars, AIM-TWX, Medline) to automate the index and have it respond to queries via the computer.

A second phase is the listing of data pieces, perhaps in an inverted file structure, under the proper headings in an index or directory, that is, a catalog. A card catalog in a library is structured as an inverted file. For example, the system would respond to a query for information about northern Arizona by looking for the heading of "northern Arizona" or its equivalent wording or symbolic representation that relates to northern Arizona. The list will usually contain some indication of where the documents are stored. Sometimes, the list may consist solely of potential sources for the user to contact to get information; other times it will contain addresses for the system to access, transform, and disseminate information to the user.

The card catalog is an example of an inverted file structure. Other modes do exist [6] and may be more suitable for various situations.

3.2.2 Storage Requirement

In order to fulfill the storage requirement, the system must take into account the implications of the form and content of the information, the considerations of the context, and the custodial tasks to be performed. Further technical details on each of these are given in the paragraphs below. The storage facilities must keep sufficient information or data products and supply enough memory for information or data services provided. A discussion of the distinction between information and data is given in Appendix B. For conciseness only, the word "data" is used in this section. An example of a storage facility which could perform some earth resources data storage functions is the previously discussed NASA Earth Resources Research Data Facility of the Manned Spacecraft Center (MSC) in Houston, Texas. The most distinguishing features of requirements on storage facilities for earth resources information are huge volumes of data at high transfer rates to be kept for long periods of time such that any part may be accessed quickly for a diverse community of users.

3.2.2.1 Form Implications

The physical form of the data has immediate implications on their accessibility, permanence, bulk, and incremental cost. An operating facility should be capable of optimizing these parameters under dynamic conditions. Except for special forms, the physical form of the data seems to be oriented toward man or machine, depending on its expected use.

Human oriented forms are the most bulky, most permanent, and least accessible in large quantities. Documents alone present a formidable problem as has been documented elsewhere [7]. Since the earth resources discipline is a subset of the science and technology field, the forms and standards of the Committee on Scientific and Technical Information (COSAIT) should be used when possible. For example, the Joint Committee Printing units (JCP) are 8-1/2" x 11"; however, computer listings and maps do not in general conform to this standard. Books and other library materials are even less standardized. Depending upon the source of data, multiple copies may either need to be stored or they may be produced upon demand. Although there are advantages of rapid retrieval for small orders using hard copy and duplication machinery, such as the Xerox equipment, the incremental cost for storage and handling becomes astronomical if this is the sole technique to handle earth resources document requests. To emphasize the variety of documentation that should be considered, some examples from the more than 175 types filed at the Documentation Repository and Technical Library at the Marshall Space Flight Center [8] are listed below:

- Specifications, standards, manuals, handbooks and procedures
- Test reports and procedures
- Technical reports
- Progress reports
- Study reports
- Engineering drawings and parts lists
- Interface control documents
- Engineering bulletins and directorate policy

Photographs comprise a major portion of earth resource data. Not only are large files already in existence (MSC, Jet Propulsion Laboratory, Air Force), but even greater volumes are projected in the future with advent of the Earth Resources Technology Satellite (ERTS) and more advanced space programs [10]. Because of the bulkiness of pictures, most imagery will probably be stored in microform or on computer tape. Maps and overlays present a special problem because of the physical significance of the scale factor. Any distortion in the physical form is a distortion of the data stored. Although this may be negligible to the unaided eye, microscopic differences may be detected by image readers which can discern 50, 25 or even 1 micrometer lines on a photograph. To some extent, existing cartographic services may be relied upon; however, some mapping will be the result of merging computation output with maps, as in crop classification.

Machine oriented forms include telemetry and computer readable items. Another distinction is between analog and digital data. Telemetry and other analog data must be recorded immediately since there is no persistence in electro-magnetic radiation. The most common form of analog storage is magnetic tape at the present state of the art. Since the information in an analog signal may be in its amplitude or frequency attributes, both must be preserved unless the specifications are known so that only the relevant information needs to be preserved. Although computer cards are the classical storage media for occasional digital system users, magnetic surfaces or more advanced forms such as crystals or bubble memories will be needed for the volume of data anticipated for an earth resources information system.

The special forms in which earth resources data are expected to be needed are microforms, raw data (including specimens which are assumed to contain their own information) and field logs. Microforms, as reported [9], include any form, either paper or film, which contains micro-images. A detailed analysis of the implications of microform technology is given in Appendix B. A microfiche system is distinctly superior to a cartridge system for the Federal Catalog System (FCS) Publications [7]. The FCS 1970 volume was 1.3 billion pages with 500 million page changes. Since earth resources information is expected to have over 16 million items per year to catalog, with the possibility of this volume increasing by two orders of magnitude over the next decade, the information explosion problem which FCS faces now can be anticipated for earth resources. For the Earth Resources Technology Satellite Program, the film processing at the NASA Data Processing Facility produces bulk and precision transparencies and paper prints in either 70 millimeter (mm) or 240 millimeter widths to meet users requirements. If other photographic images are brought into the system, greater variations in size and paper type can be expected. Since physical specimens can be very bulky and often deteriorate with handling, a minimum shipping and receiving facility, using classical techniques, could be expected to process the anticipated small number of requests for such special items.

3.2.2.2 Content Implications

The content of the data has implications on storage requirements depending on its description and tolerance for errors. If a machine representation of information represents the precise intent of the content, then only error tolerances need to be considered. However, depending on the data type, a machine representation may only be an approximation to that intent. For example, a voice message might be digitized and stored temporarily before being received by a listener. The different representations of that message are of no consequence to the listener as long as the message is not lost. Thus, speech analyzers and synthesizers can greatly reduce the actual amount of data needed to represent the message by removing redundancy. Other techniques to reduce storage requirements exist and are applicable to the ERISTAR system.

For example, the decimal number 1000.01 would be more seriously misrepresented if the first "one" digit were dropped than if the last "one" were dropped. Yet, the probability that a digit would be lost may be the same regardless of its position. Some error detection and correction techniques have been developed to help solve this problem at the expense of additional memory and computation time.

Our discussion includes both analog and digital data. Analog forms may be used to store video data, due to its compactness. However, this form implies additional processing. Digital data are logically classified as numbers, text, imagery, and linkages. The numbers may be scalars of an integer or real (also called floating point) type, or they may be grouped into multi-dimensional arrays. Although other number types exist, such as logical and complex numbers, their infrequent anticipated use does not justify a significant impact on the system design. Text implies one or more alphabets. On a computer this is usually restricted to the hardware capabilities for representing characters and form controls. However, full text documents require more extensive text capability. One approach is to treat entire pages as pictures (although some degradation in resolution is expected). As long as machine readability is not a requirement, this approach is very attractive, particularly when using microform techniques. Since text may have structure associated with it, an alphabet about the text (also called a meta alphabet) may be needed to properly specify text. Computer processed text (and sometimes numbers) are grouped together in fields which may be grouped into records. Sets of records may be grouped into files and files may be collected into a data base. For example, abstracts and citations are formatted text.

Programming standards are needed to provide a high degree of transferability from machine to machine. For example, a standard language such as COBOL which has data structures like those above should be adopted. Imagery is by far the greatest data type according to volume as explained under context considerations in the next section. Imagery includes diagrams, cathode ray tube (CRT) displays, plots, and photography. Besides conventional black and white photographs in any spectrum, multiple images from various frequencies may be combined to make color scenes. If the correlation between color selection and the frequency chosen is different from the rainbow, then the scene is said to be in "false color". This may emphasize the information contained in the picture.

The last type of data is linkage. If all items were in one computer system, linkages between associated items would be a special case of integers. However, with people performing some of the system functions, these linkages may also take the form of human interaction. Since this human ability to interpret some types of data (e.g. photographs) cannot be entirely duplicated by machine, a continuing education program in data analysis needs to be maintained and improved.

3.2.2.3 Context Considerations

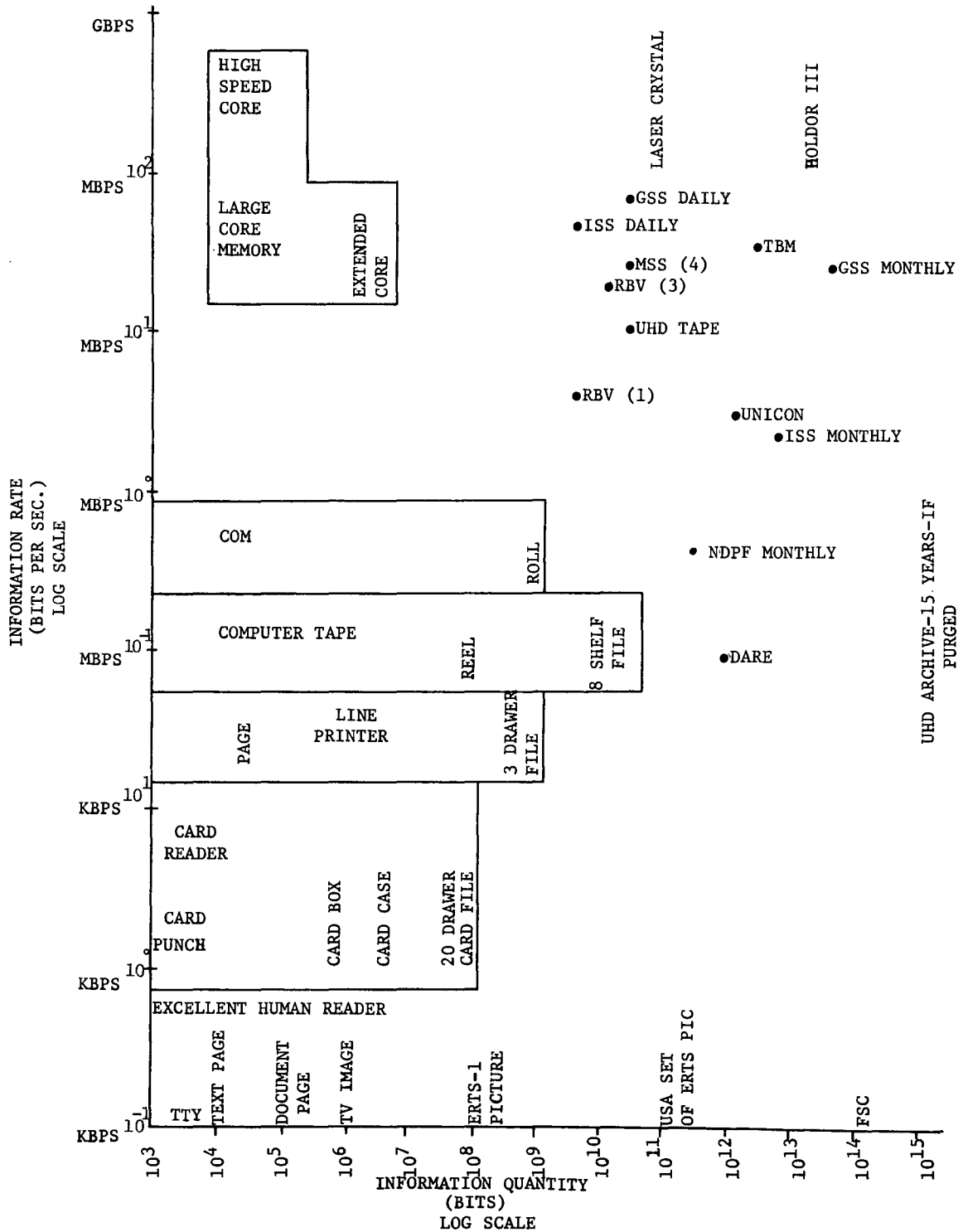
The earth resources information system implies large quantities of data at high data transmission rates to be archived for long periods of time and numerous interdata relationships which are expected to change with time. To some extent the user requests are presently being anticipated; however, the system design needs to be adaptive and to some extent predictive if good user service is to be provided. The data for these projections was collected from a variety of sources [10]. According to the Ground Data Handling System (GDHS) specification outlined in Exhibit B-7 (Appendix B), the current data rates on each typical data channel may be 15 mbps from which a total of 1316 bulk processed images are processed per day using the down link only 30 minutes per day. Multiple copies and precision processing images are not included in this count. If the usual ratio of 4 high density digital tapes (HDDT) per scene is used, then 188 HDDT tapes would be produced per day or 67,000 HDDT tapes per year without counting multiple copies.

The Information Flow vs. Information Quantity pictorial (Exhibit 3-4) and its annotation, found in the Glossary in Appendix G, provides a convenient means to compare the various data products which a general data handling center might consider. The log-log plot allows comparison of items which differ by several orders of magnitude and represent the spectrum from microscopic entities such as computer characteristics to macroscopic entities such as FCS. Whereas the common units of bits are convenient in one part of the domain, images or documents are the preferred units of information at the other extreme. Another contrast between the left half and right half of the Exhibit is the importance of errors. In electronic data processing memory systems, random errors are not tolerated. However, reproductions of documents are expected to have some loss in resolution and stray noise spots.

Horizontal boundaries of an area give the minimum and maximum storage size for a particular technique. The vertical boundaries show the minimum and maximum rates. For example, computer card files extend from 1 card (480 bits) to a 20-drawer card file (10^8) bits. These boundaries depend on which manufacturer's specifications are used. Within these limits, the enclosed areas indicate that it is within the state-of-the-art to produce equipment with these characteristics. Of course, a complete pictorial with all possible techniques would have many areas overlapping and have a cluttered appearance. However, enough has been shown to illustrate the magnitude of the storage parameters in the developing imagery technology. Note for example, that per the requirements to fully support the Growth Space Station (GSS), it would require memory capability two orders of magnitude greater and processing rates two orders of magnitude greater than the NASA NDPF capabilities at GSFC [27].

The argument of purging [10] being the answer ignores the fact that what is of no interest to one user may be vital information to another user. There is a natural tendency to not throw something away which may be very expensive to obtain.

EXHIBIT 3-4: INFORMATION RATE VS. INFORMATION QUANTITY



When asked how long earth resource data should be archived, many users say "forever!". It seems more reasonable that various levels of storage should be maintained. These may include:

- High speed core
- magnetic disc or drums
- drawers (for cards and microfiche)
- active shelves (for tapes, documents and specimen)
- warehouses (for archival copies)
- user stores (for private collections).

The order given here is descending in accessibility to the retrieval function.

The level at which items enter the storage system and the length of time on each would vary as the system load varies. Dynamic algorithms need to be developed to optimize the operation. Long term trends such as ten-year studies may require special packaging.

The initial relationships among the data may be carried without any significant problem until purging begins. Local updating in a computer data base could use a generalized management information system. However, some of the relationships introduced by analysis after data is collected are more difficult to update. Typically, this collection process takes two years to complete [11,12]. However, some of the information will lose its usefulness if delays longer than eighteen days are introduced by the storage techniques. The effects of computer classification of images could be even greater.

3.2.2.4 Custodian Tasks

Some of the custodian tasks which are expected to have an influence on the design are maintaining storage integrity, enforcing quality control measures, and formulating policy recommendations to cope with an evolving internal work load and diverging external relationships.

The task of maintaining storage integrity is very important since the earth resource system is not backed up by any single existing system. Since the first few years of operation are expected to emphasize the storage functions, filing errors may not be detected early enough to be completely corrected. Not only should the errors be detected but they should be analyzed to locate the source, whether it be from humans or machines.

Quality control includes the precision of data, the preservation of form, and the preservation of resolution, contrast, and color quality. Although the precision of raw data is limited by its source, errors may be introduced by truncation or algorithmic techniques as well as from material or mechanical failures. To minimize the effect of errors on vital data, error detection and correction techniques should be employed in those subsystems which can be expected to perform unreliably. For example, magnetic tape has as a design parameter the probability that a bit may be dropped. Form preservation is a problem most noticeable in imagery. Thus, form-stable material needs to be used for storage of master prints. Additional form preservation considerations are discussed in the transformation section 3.2.4. Although it is difficult to relate the technical definition of resolution and contrast given in Appendix B to what can be seen, aging of materials generally causes a loss in resolution with time. Depending on the material, this may be accelerated by light, heat, vibration, or magnetic fields. Since the component parts of color scenes are expected to be stored, color preservation for long periods of time is something of a luxury. However, some of the false color combinations are chosen to emphasize the information in an image. Thus temporary storage facilities should preserve color quality.

The custodian function of providing policy recommendations will be a valuable asset to management. More detail on this management problem is given in Chapter 5. Problems can often be detected by noticing changes in operational parameters. Procedures need to be developed for first and second order contingencies to cope with major problems which could produce disasters. For example, working tapes and backup copies should not be stored at the same physical location. Both internal and external standards need to be established as early as practical. These would include, but not be limited to, data communications interfaces, character sets, programming languages, job control languages, and file systems interface. Criteria need to be established for real time linking into external networks. Besides creating an increase in work load, some control instabilities can accidentally be generated by careless connections.

3.2.3 Retrieval Requirement

In order to service all user requests satisfactorily, several retrieval requirements need to be met. Foremost, the system should be able to recall and retrieve any relevant data item which is stored in it and should also be able to recognize when a pertinent data item is not in the storage system. The retrieval function is basically one of matching the formalized user query to the data base in order to draw out those items that are relevant to that query. In the process of searching, irrelevant material should be eliminated. Here the organization requirement, discussed in this section will be employed. User complaints are inevitable unless the system responds in a timely manner. Unless users may interact with the system, it would have little distinct advantage over existing archival facilities. Finally, the entire earth resource discipline is undergoing rapid change so that new developments in retrieval capabilities is needed to meet the challenge. Some technical details and implications of this requirement are presented in the following sections.

3.2.3.1 Perseverence in Retrieval

Directly or indirectly after a request is formulated, the system should reference all the data items which might be retrieved. The participation of the search work load between humans and machines is an operational parameter which should be optimized to be cost-effective as soon as user statistics are known. Depending on the organization of the data stored and the nature of a search request, the proper search strategy should be selected and the search pursued through as many levels in the storage hierarchy as can be justified. Simple computerized searches such as RECON or NASIS [13, 14] can be very helpful in locating citations which deserve further study. Browse files such as the catalogs planned for the Earth Resources Observation System (EROS) data center are very helpful for unstructured searches. However, the distance to a central location and the time it takes to go there may restrict such capability to internal use. If the organization or information requirement has been properly carried out, the identification and location of relevant information is facilitated. If there is adequate care taken when the data is stored, the physical retrieval function can be grossly simplified.

3.2.3.2 Noise Elimination in Responses

The largest source of noise to be eliminated is irrelevant material. Eventually, the user must decide in detail what is relevant; however, a careful choice of exclusion criteria such as indicated in a thesaurus [40] can eliminate great quantities of data. A systematic method of specifying relevance needs to be developed which is compatible with the file structure and indexing scheme. For example, items of lower relevance can be dropped to lower levels in the archives. However, on a particular request, the readily-retrievable items should be identified with an indication of the degree of effort which is anticipated to extend the search.

Other noise, whether it be due to human errors or material defects, should be detected by the system so that it may be corrected. However, a feedback mechanism should be provided users so that their observations and criticisms on relevance are not lost.

3.2.3.3 Timeliness of Responses

The foremost reason that response time should be small is that the information retrieved may lose its value with time. In some cases, the user is aware of this and can alert the system by making a rush order. However, unless controlled, abuses of priorities can destroy their usefulness. Improving overall system performance tends to give the average user the best service. Many techniques are appropriate to make a better system. For example, notice the difference in number of request to process when the user is given what he wants the first time instead of being required to re-enter a modified request.

Consistency in the system response is a requirement for user satisfaction. In experiments with users at time sharing computer terminals, there were more complaints about the variance in response time for some requests than on the amount of time it took the system to respond. Over long periods of time as the number of citations grows, an increase in time is expected. However, unnecessary short term variation should be eliminated.

Knowledgeable users are tolerant of reasonable delays for difficult requests. However, users need to be informed of the difficulty of their request in order to adapt to responses. User education combined with system interaction capabilities can solve this problem.

3.2.3.4 Interaction with Requestor

The primary interactions which users might expect to experience are personal, terminal, and network ties. In order to minimize the difficulty of interaction and preserve its advantages, appropriate standards, adequate documentation and education programs need to be provided. Interaction is of value to the system as well as to the user. If properly designed, unnecessary data can be given lower priorities automatically.

The value of personal contact is extremely high. Someone must format requests and interpret the corresponding system response, when necessary. It is unreasonable with existing equipment and techniques to expect all users to learn to operate the automated portion of the system. Some of the photographic interpretation techniques appear to be an art which must be passed from person to person using special equipment. Part of the referral function can best be performed by people who are acquainted with remote retrieval techniques. For example, referral librarians routinely perform this function for the open literature.

The terminal contact would provide man-machine interaction by knowledgeable users and center personnel. There would be several computer languages, tutorial programs, library programs, editing programs, retrieval programs, and some directory assistance provided through the terminal. The potential for fast response through terminals makes them very attractive. However, a realistic cost analysis needs to be performed to determine the number of terminals at each center.

The possibility of real-time ties into other networks needs to be studied carefully to be sure that the advantages outweigh the disadvantages. In this case the necessity for standards and agreed-upon specifications can hardly be overemphasized.

3.2.3.5 Technique Development

The area of earth resources has felt the impact of remote sensing technology. However, the full impact of a nation wide computer network supporting earth resource information activities is yet to be felt. In order to make use of these vast volumes of data, existing techniques need to be applied; however, it is anticipated that they will be inadequate.

Particular attention should be given to hardware development. Major breakthroughs such as the "push broom scanner" or laser memories could revolutionize the approach to information management. When the Skylab hardware [15] is flown, the full impact of onboard human control of an earth resource observation system can be assessed.

Software development is expected to benefit the earth resource effort in two ways. One is the implementation of algorithms to solve problems as they are identified and analyzed. The other is the development of total systems with new capabilities, particularly in image processing which is only in its infancy.

Finally, the human element can be expected to make a greater contribution as experience is gained with new equipment and techniques. The interdisciplinary nature of the earth resource technology could open new avenues of education and research in university and industrial communities.

3.2.4 Transformation

The transformation requirement may be subdivided into four functional areas: (1) conversion, (2) reduction/compression, (3) analysis, and (4) display. A discussion of each area follows below.

3.2.4.1 Conversion

Data gathered from many sources will need to be converted in form or medium. For example, earth resources information sensed remotely via satellite or aircraft will have to be recorded, organized, stored in a reasonable medium, retrieved, transformed as needed and disseminated. This implies that the conversion function takes place at the storage and again at the dissemination points in the process, vis-a vis the form. Part of the transformation function will no doubt include much image processing. Note that the conversion function implies a standardization operation so that the various data forms will be uniform. As an example of the conversion function, consider the operation of the NASA Data Processing Facility discussed below in Appendix B.

3.2.4.2 Reduction/Compression

The mere volume of the data involved in a earth resources information management system can be staggering. The ERTS/A satellite is capable of transmitting 15 million bits of information every second to earth.

This is the equivalent of an Encyclopedia Britannica every few minutes [18]. In order to handle this problem, some transformation activities are crucial that will reduce the amount of data involved in the earth resources information flow.

The storage problem alone indicates the potential for microform, which includes microfilm, microfiche, ultra-fiche and other various photo-reduction media. As discussed above, NDPF already has plans to become involved in microfilm processing. Another technique is the elimination of redundancy in the data. For example, consider the ERTS Satellite broadcasting the same scenes over and over as it passes over the same area. It might be more reasonable to record the original image and then transmit, record, and store only the changes that occur. A third technique is the proper coding of data to compress it. This is generally in reference to computer-oriented data forms. However, documents can be reduced by being abstracted, extracted, summarized, or reviewed.

Of course, a most important method of reducing the amount of data in the earth resources information flow is to organize it properly, as discussed above in section 3.2.1. This means good content analysis and indexing techniques must be implemented. If one can easily find those few items of information really needed to solve a given user problem, the information flow can be drastically reduced.

3.2.4.3 Analysis

The data, regardless of form, may not in and of itself, be able to convey the information needed by some of the users. For example, an ERTS satellite picture of southern Indiana will not be able to solve the problem of determining the extent and degree of corn blight in the area. There will be a requirement for extensive analysis on the data represented by the picture.

There are several types and modes of analysis that various user needs are going to require. Making inferences, both deductive and inductive, to arrive at conclusions with are not explicitly found in the stored data base is one very important set of procedures. This is the gleaning of information from the data, and the interpretation of that information. Some of the techniques associated with inference are statistical analysis, prediction, estimation, extrapolation, and interpolation.

Another set of procedures relate to automatic recognition of patterns. This complex topic is discussed in some detail below in Appendix B. It relates to the identification or classification of distinguishable patterns. For example, from a signal such as a photograph, one could try to specify whether the various regions were urban or rural.

A third set of procedures involves modeling and simulation techniques. These very important methods will be an integral part of any total earth resources information management system. The purpose is to assess and understand the impact of certain variables on the environment. For example, a state planner in Alaska may desire to know the effects of the planned oil pipeline on the economy and ecology of the state. A model, that is to say, a physical or symbolic representation or abstraction of reality, can be built and manipulated to simulate the actual situation under consideration. Moreover, decision models and operations research techniques may be used to aid in planning and making policy decisions. For example, all of these models will require data from the information system to solve the problems under consideration. And the results will be a new source of data for the system to handle. While the system may not have the capability to develop such models, it is essential that those agencies and investigators working on such models to be incorporated into the system as data sources. The information system can contact them as needed for their models as well as their results. Thus the system can incorporate the modeling and simulation functions into its operational scope.

3.2.4.4 Display

In order to insure user satisfaction with the information system's output, there must be consideration given to the mode in which that output is displayed to the user. The right data presented in the wrong manner could easily lead to user dissatisfaction.

One prime problem in dealing with remote sensing imagery from satellites is that the images may require further refinements in order to glean enough information from them to solve the various user problems. Image enhancement procedures that can highlight hidden details are an important solution. No doubt such procedures could be extended to airplane and ground data as well.

Some data may require presentation in the format of a table, graph, chart, figure, or exhibit of one sort or another. Many people such as Dr. James Anderson of the University of Florida [19], and Mr. Curry and Mr. Shoenin of the Tennessee State Planning Office [20] have discussed the desirability for thematic maps for doing such things as land use surveys. Moreover, even if the data is presented as a printed document, the format must allow the reader to easily see and understand the information he desires. This includes the photogrammetric and cartographic activities required to produce specialized maps not available elsewhere.

One final point is valid for all transformation activities. The earth resources information management system must be interactive, allowing the user to interface with the system. The user should be able to modify or clarify his initial query after seeing a segment of

the information systems' initial response in order to improve the desirability of that response. Moreover, a successful and widely used system most likely implies the capacity to communicate with the user in a natural language or one in which he can easily understand. This last aspect will require quite a bit of research and development in order to achieve satisfactory results.

With the transformation function in operation, an earth resources information management system such as ERISTAR will be quite capable of going beyond the services offered in "usual" information system without such requirements. With the new and easily accessible data bases on earth resources now in existence or on the drawing boards, ERISTAR should be able to provide a wide repertoire of satisfactory information services and products.

3.3 CONSTRAINTS AND CRITERIA FOR THE INFORMATION PROCESSING SUBSYSTEM

In line with the total systems approach, the next logical step is the delineation of appropriate constraints on the subsystem and of criteria for the selection of the best feasible alternative subsystem design approaches. The specification of these controls, these constraints and criteria, will enable the design group to make the necessary trade-offs in that selection process.

3.3.1 Constraints

A constraint is an absolute control, setting a bound and imposing a limit on the acceptable levels of a specific variable or aspect of the subsystem. Constraints can be imposed on the information processing subsystem involving such things as physical, financial, timing, and policy considerations. These controls serve to designate which alternative designs are feasible.

For example, one constraint might state that the annual capital expenditures could not exceed a certain specified budget, another constraint might specify that the subsystem must not infringe upon the charters and responsibilities of existing government agencies or their information systems. Any information processing subsystem design alternative that exceeds such limits is infeasible and cannot be considered further.

The list of constraints upon the subsystem is outlined below.

- o Financial

- the annual operational cost, including the amortization of the initial cost to design and implement the subsystem, of the information processing subsystem must be within reasonable

limits. The setting of these limits, \$560 million per year for fiscal years 1973 1977, is discussed in Appendix B.

- o Timing

the initial information processing subsystem must be operational in the near future, with the final design in operation within the foreseeable future.

- o Consistency with Existing Agencies

the information processing subsystem will not infringe on the charters or responsibilities of existing agencies and their information systems.

- o Technology

the information processing subsystem must be in line with existing technical states of the art, even as they change over time.

With the constraint set defined, any feasible alternative design for an information processing subsystem of an earth resources information management system should be at least minimally acceptable. Now, one needs to pick the best design possible.

3.3.2 Criteria

A criterion is a relative control, specifying a dimension or aspect of the overall worth of a particular design alternative. It is a scale, along which one aspect of worth can be measured or determined. It provides us with a standard of comparison. Some of these dimensions will relate to performance, risk, policy, and cost/effectiveness.

For example, one criterion might be the speed with which the system can respond to a specific query for information. The idea is that, all other things being equal, the system design alternative that leads to a smaller response time is preferable.

The criteria for the information processing subsystems are listed below. Note that they are divided into two classes; Systems Effectiveness, and System Operation and Administration Efficiency; the basic breakdown of cost/effectiveness analysis.

3.3.2.1 System Operation and Administrative Efficiency

This set of criteria relates to the consumption of available scarce resources for the operation and administration of the information processing subsystem. These "cost" considerations are outlined below.

It is noteworthy that for all but the first two criteria, the system design that is most desirable is the one that obtains the maximum of the criterion in question if all other things are equal.

- o Cost

The net annual capital expenditure required to keep the system in operation, including the amortizing of the expenditures required to design, implement and set-up the initial system and to evolve into the final system design.

- o Software and Hardware Requirements

The physical equipment (hardware) and programming (software) needed to achieve subsystem requirements, including considerations of the degree to which existing information system facilities and efforts are duplicated.

- o Maintainability

The ease with which the system can be kept operational.

- o Reliability

The extent to which the system can be made capable of operating as designed, including considerations of the risk or likelihood of the subsystem to fail to meet its design specifications and performance requirements.

- o Transferability

the extent to which the information processing subsystem can transfer processing capability from one segment of the system to another as deemed necessary.

- o Adaptability

the extent to which the subsystem can easily be modified in response to either changes in the environment (with regard to users, sources, technology, economics, politics and society, and growth), or to planned evolutionary design changes; including considerations of the system's research and planning activities.

- o Monitoring Capability

The extent to which the system can keep tabs on the information processing subsystem, on the environment, and on the uses of the processing subsystem, so that the managers of the system can have the proper information and means by which to control

and improve the operation of the system; this includes considerations of feedback, usually in terms of a management information system.

- o Manageability

The extent to which the information processing subsystem can easily and effectively be controlled, improved, and administered; including considerations of internal and external communications and implementation.

3.3.2.2 Systems Effectiveness

This set of criteria relates to the ability of the information processing subsystem to achieve its requirements. These "benefit" or "effectiveness" considerations are outlined below. Note that for all but the first three criteria, the system design that is most desirable is the one that obtains the maximum achievement of the criterion in question if all other things are equal.

- o User Effort

the exertion, mental and physical, required of the user in order to obtain information from the system, in terms of both cost and convenience.

- o Response Time

the time lag between the entrance into the information system of a user with a need for information and the delivery of the final response of the system to that need.

- o Entry effort

the exertion, in terms of cost, time, and inconvenience, required by the information processing subsystem to select, acquire, and collect new data and information into the system from the various sources, with the selection process linked to user requirements.

- o Availability

the extent to which the information processing subsystem is ready, operational, and convenient to use.

- o Accessibility

the extent to which desired information is obtainable and can be retrieved from the system, in terms of both intellectual access (identification) and physical access (location.)

- o Recall

the extent to which the system can retrieve (draw out) of its store all of the relevant bits of information in response to a specific user query or request.

- o Precision

the extent to which the system can insure that the information presented to a user in response to a given query is relevant to that query.

- o Coverage

the extent to which the system has obtained the comprehensive set of all information deemed relevant to the users of the system, in terms of the depth, breadth and scope of the data collected by the system.

- o Security

the extent to which the system can protect the stored files of information both from deliberate or accidental erasure or modification (data base integrity) and from being used by unauthorized personnel, as well as protect the privacy of both sources and users.

- o Interaction

the extent to which the information processing subsystem allows the user to enter his initial request and then alter it in midstream to get a better response, as well as helping him to interpret his needs and the system's response to those needs; this feedback mechanism includes considerations of human engineering and man-machine relationships.

- o Political Acceptability

the extent to which the system is worthy of and capable of finding political support from the general public and from the established institutions of society, including considerations of public awareness, scope, user satisfaction, general participation in the design and control of the system, consistency with current legal practices, and the overall utility and impact of the information system upon society.

The criteria and constraints have been outlined for the information processing subsystem of an earth resources information management system (ERISTAR). However, it should be noted that they do coincide directly with the controls, and are consistent with the objectives and requirements, of the overall system. The next task is the detailed analysis needed to specify alternative approaches to the information processing subsystem.

3.4 APPROACHES

Having defined the objective, requirements, constraints, and criteria for the processing subsystem of ERISTAR, the next step in the systems approach is to delineate a set of feasible alternative approaches for a subsystem design. This section describes the procedure for executing this phase with respect to the processing subsystem.

3.4.1 Necessity for Considering Total System Approaches

Considerable difficulty is encountered in attempting to define alternative approaches to the processing subsystem. Processing functions interface so completely with those of acquisition, user service, and system management that it is impossible to design the processing subsystem independent of the other three subsystems. The alternative is to postulate a set of total system configurations and to describe the processing functions within each.

The procedure for identifying total system alternative approaches is initiated by first establishing the spectrum of possible systems. The dimension over which the approaches range might be termed "capability". Very closely correlated with capability are such measures as immediacy of implementation, complexity, and cost. Hence, at the lower end of the spectrum is a system which is immediately implementable, simple, inexpensive, but not very capable. Such a system is largely operated by people, with little reliance on automatic equipment. At the upper end of the spectrum is a system that is implementable in the distant future (say, 1985), complex, expensive, and highly capable. It is highly automated, with a minimum reliance on people.

Having defined the spectrum of total system approaches, the next step is to formulate five alternative approaches which span that spectrum. The following sections describe these five approaches in increasing order of implementation time, complexity, cost, and capability.

3.4.2 Linked Network Approach

The linked network approach consists of many Earth Resource centers linked together by a communication network and management structure. Although individual centers would differ from each other because of their emphasis, the functions of acquisition, indexing, cataloging, reproduction, archiving, retrieving, referral, and dissemination would be performed within the network. However, the functions of analysis and interpretation would not be performed by network centers. Thus the linked network users would need to be sophisticated enough to analyze their own needs and synthesize the desired information from the data they receive. In one sense each center is a referral agent. That is to the extent that the center can service a request, it will do so. However, uninformed users will be referred to proper facilities to process their request even though these facilities are not members of the network.

3.4.2.1 Illustration of the Linked Network Approach

In order to illustrate the linked network approach, some existing or planned earth resource activities are linked in Exhibit 3-5 and their possible relationships are described. The reader is cautioned that this illustration is not a proposal but an example of how the linked network concept could be implemented. However, since McDonough's presentation [35] was the principal source for the data in Exhibit 3-5, the illustration is very realistic. The primary departure from the established system is the inclusion of a Land Use Planners service center. Although all centers are tied together by phone lines and mail service, only the principle flows of imagery, data, and literature citations are shown. Since all centers are housed in some existing agency, the only management structure to be suggested concerns the network operations. An interagency committee could establish policy and guidelines for the network much like a board of directors coordinates many companies in a conglomerate.

3.4.2.2 Justification for the Linked Network Approach

The linked network approach is a refinement of "the universal data network system" selected by the Ad Hoc Interagency Policy Group on Earth Resources Survey Program in their report [36]. The other two approaches which they considered were: 1) a national data center and 2) utilization of separate data networks.

Although the linked approach in its minimal form is only a small modification in the structure of existing systems, its value to a new community of users could be very high. Since the existing entry for a user from the public domain is into an archive, only those requests by proper index terms can be serviced efficiently. However, by adding user oriented centers which are linked into the network, less precise requests could be serviced.

3.4.3 A Hierarchical Earth Resources Information Network

The earth resources information system can be portrayed as a hierarchical network in which each node or center can be seen from both a function and an organization viewpoint. The operation of such a system and its inherent merits will be discussed below.

A user, a person with a problem and requiring some information, enters the system at a nearby entry point. These points have been called Current Awareness Centers (CAC) [7]. Here his request is analyzed, formalized, and processed. The system may respond by disseminating to the user a list of information sources for the user to contact, a list of documents for the user to track down, a set of documents for the user to read, physical samples or raw data for the user to analyze, a set of displays showing the results of the system analyzing the data on behalf of the user, a list of algorithms (or even the computer programs themselves) to do some analysis of raw data, or combinations

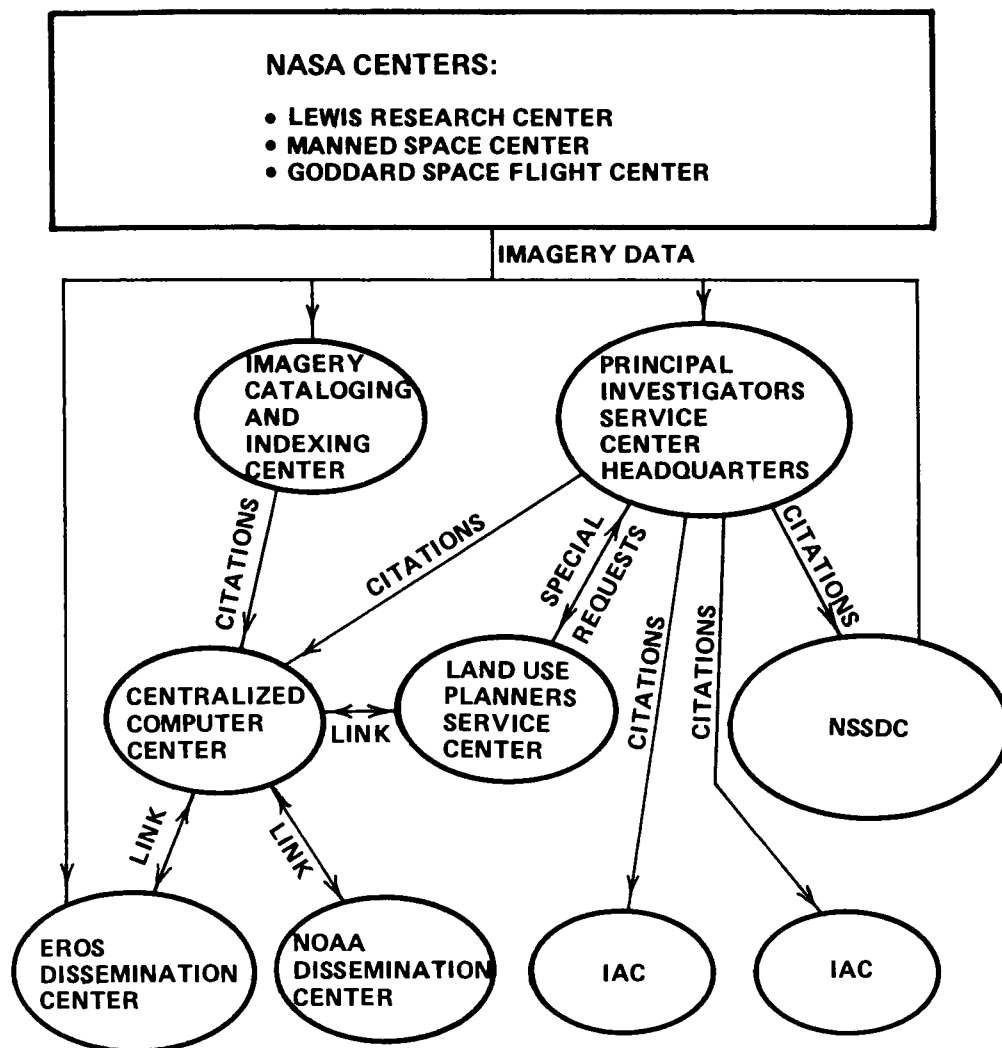


EXHIBIT 3-5: LINKED NETWORK ILLUSTRATION

of the above-mentioned alternatives. Thus the output, usually given out at the entry point, can be documents, physical samples, imagery data, or raw data. Moreover, provisions for mail or communication of output at the user's place of residence is not ruled out.

The system matches the user's query against its catalog of sources and items in store, identifies those deemed relevant to the query, locates them, and gives a list of items, the items themselves, or the results of analysis of the items to the user.

Data and knowledge of data sources are being acquired by the system in order to be able to respond readily to the anticipated requests of the users. The data itself is acquired, collected, transformed into a proper medium, organized, and stored. This includes analysis, classification, and indexing of the data. Moreover, the data can be raw data, data processed to some extent by the system or by earlier users, surrogates describing the data or information content, and lists of data sets available at various sources. Note that a surrogate of the data is made and stored, reflecting the nature and location of the data. This surrogate notifies the viewer of the existence and location of the data it represents and aids in the matching of user queries to relevant data products.

The information storage and retrieval system is depicted conceptually in Exhibit 3-6 below. Included are considerations of the user and the funder, who has a set of goals toward which he is willing to allocate certain amounts of scarce resources such as capital. This allows the funder a level of control, both in terms of budget levels and in terms of power ("He who pays the piper calls the tune"). Moreover, the management of the information system is given a prime role, monitoring the system, evaluating it, and generating a series of decisions and actions (policies and procedures) that will lead to an "optimal" system. Management must incorporate the needs of the users and the funder controls into a coherent structure by which they can manage the system. Of course, they are directed by their own goals that they want the system to achieve.

The control of the system will be based at a central focal point, sometimes called an Information Analysis Center (IAC) [7]. Here the data acquisition and processing functions will be located and/or monitored. The organization of the system is illustrated below in Exhibit 3-7. The central focal point is the Information Analysis Center (IAC), surrounded by Regional Centers (RC). Attached to the regional centers is a series of State Centers (SC) which have, in turn, a series of Current Awareness Centers (CAC) attached to them. This is a hierarchical network structure. More levels can be added if deemed necessary, of course.

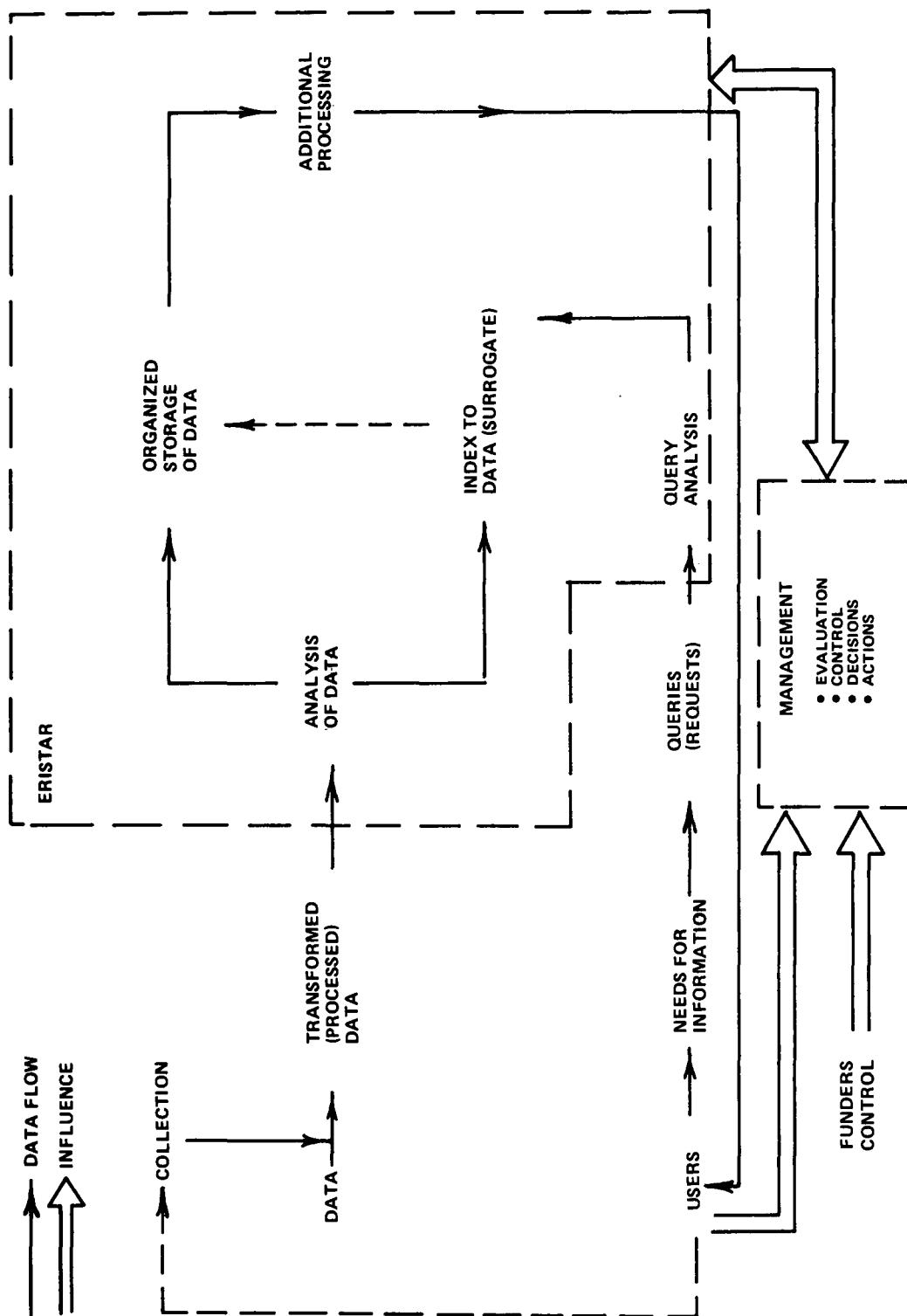


EXHIBIT 3-6: EARTH RESOURCES INFORMATION MANAGEMENT SYSTEM (ERISTAR)

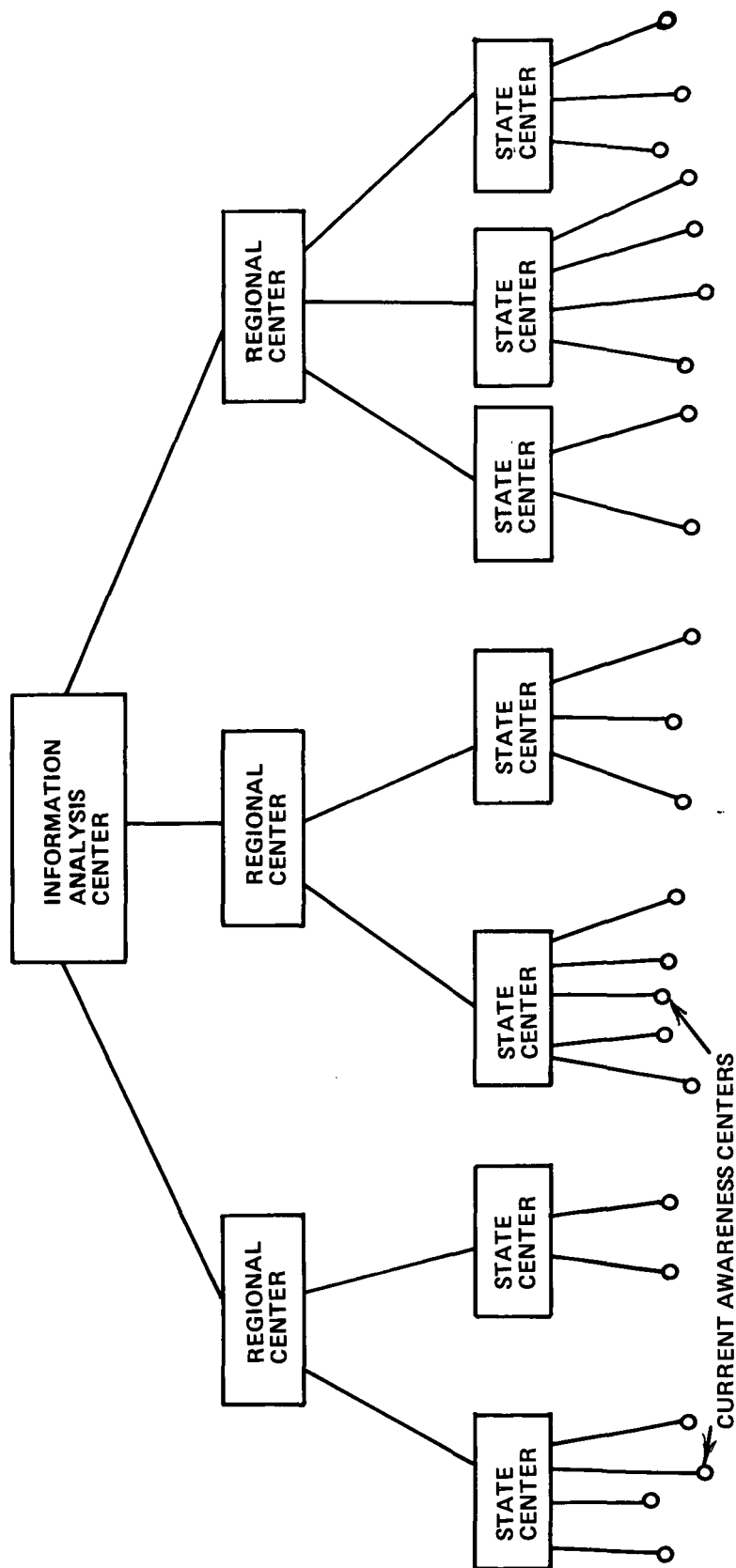


EXHIBIT 3-7: HIERARCHICAL NETWORK PLAN

Each center will be specialized in scope, with the degree of specialization increasing as one goes down the hierarchy. Thus the size of the data base stored in the center and the number of various services the premises decrease with the hierarchical level. The system will be national in scope, with some international centers as a future possibility, so that the major issues are organizing the states into regions and specifying the sites for all the centers. The purposes of the regional and state centers are for them to be storage depots and communication links, as well as administrative links in the organizational management hierarchical structure.

The existing government structure could be used as a basis for organizing the information system. For example, the system might be centered around a separate federal agency, set in the federal bureaucracy somewhere. The state centers will be located near the seats of the state governments, and the current awareness centers near various user residences. One of the important details to be worked out is the communication links between centers; another one is the specification of the degree and direction of specialization in each center.

Management is an important segment of the hierarchy. The specific plan of organization and authority will have to be worked out properly. One main issue will be the degree of autonomy each level in the hierarchy has over its own affairs. Another issue will be the funding arrangements for the system.

The system will be set up initially using a decentralized format. The Information Analysis Center will generate catalogs, both indexes and directories, for existing earth resources information systems. These existing systems will do some analysis and may serve as the current awareness centers. The system will have only a limited amount of automation associated with it. However, the system will evolve eventually into a full-scale hierarchical information network.

3.4.4 UNISTAR - Derivative Network

This systems design is based upon the ideas put forth in the UNISTAR report [7], with extensions and elaborations in several areas. The design is intended to be compatible with UNISTAR, but specialized to the earth resources information areas. All aspects of the design are specified at least to a limited degree in order to provide a framework within which to describe the processing subsystem.

3.4.4.1 Management and Funding

The Earth Resources Information Network (ERIN) will be administered by the Earth Resources Information Agency (ERIA), a new federal agency whose director reports to the President. Initial development and continuing operation shall be funded by Congress. A nominal fee may be charged each user to meet the direct costs of his request, but no attempt will be made to amortize the total system cost.

3.4.4.2 Data and Information Acquisition

The process of obtaining earth resources data from original sources will not be significantly different in ERIN than it is at present, allowing of course, for normal growth in technological capability. The collection functions will be coordinated by ERIA but will remain the responsibility of those agencies with expertise in the appropriate areas. For example, the Department of Agriculture has an on-going program to collect soil samples and classify soil types [37]. This program constitutes a valuable source of information for ERIN as well as being useful in its own right. In the area of remote sensing of earth resources data, NASA is especially qualified because of its expertise in the use of satellites and aircraft and its broad experience with remote sensing techniques [35]. But regardless of who collects the data, the important factors are:

- o make the data available to all qualified users rather than just to the source agency by introducing them into ERIN,
- o minimize redundant data collection programs through coordination by ERIA.

3.4.4.3 Organization and Structure

As the name implies, ERIN is organized as a network, the nodes of which are of two types - Information Analysis Centers (IAC) and Current Awareness Centers (CAC). (The name "Current Awareness Center" comes from the UNISTAR report - a name more descriptive of the functions ascribed to the center here might be "User Service Center"). The nodes are connected by communication links of sufficient complexity and capability to satisfy the requirements of the centers. In general, each IAC will be linked to every CAC and each CAC will be linked to every IAC. The system is illustrated in Exhibit 3-8 below. Some IACs and some CACs may also be interconnected. The operation of the CAC's and the communications network will be the responsibility of ERIA. The IAC's will be coordinated by ERIA but will be administered by the appropriate discipline - related agency.

3.4.4.4 Information Analysis Center

The Panel on Information Analysis Centers of the Committee on Scientific and Technical Information (COSATI) gives the following definition of an information analysis center [38]:

"An information analysis center is a formally structured organizational unit specifically (but not necessarily exclusively established for the purpose of acquiring, selecting, storing, retrieving, evaluating, analyzing, and synthesizing a body of information and/or data in a clearly defined specialized

INFORMATION ANALYSIS CENTERS

CURRENT AWARENESS CENTERS

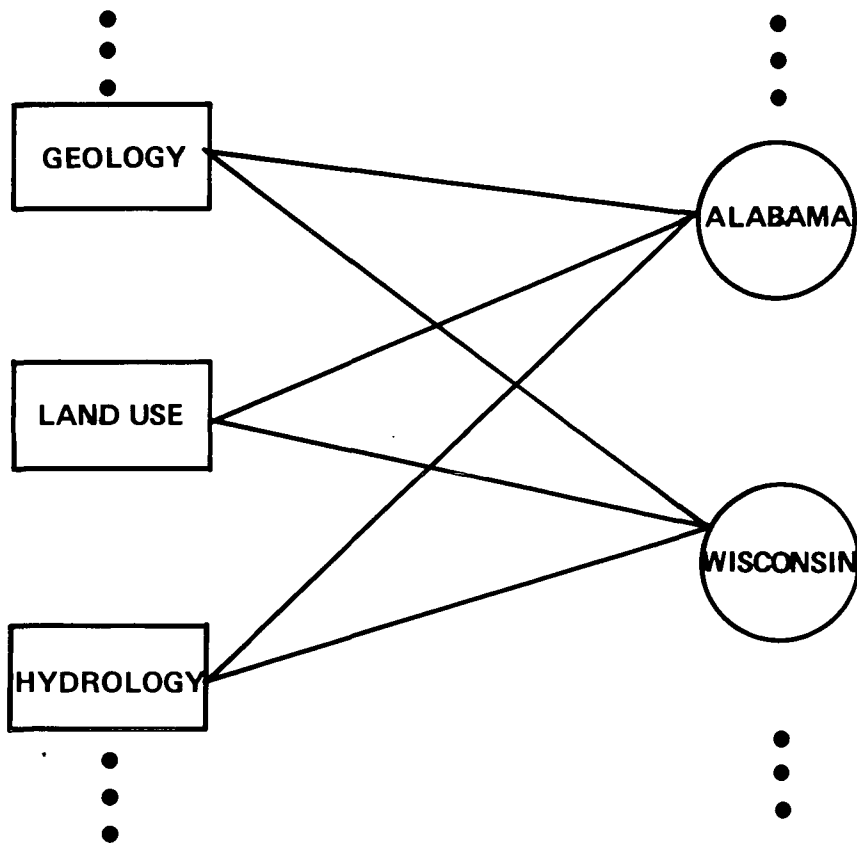


EXHIBIT 3-8: SAMPLE ERIN NETWORK

field or pertaining to a specific mission with the intent of compiling, digesting, repackaging, or otherwise organizing and presenting pertinent information and/or data in a form most authoritative, timely, and useful to a society of peers and management."

The panel further identifies 119 federally supported centers which meet this definition. A number of these are concerned with information in the earth resources areas. The IAC concept proposed here is compatible with that definition except for the emphasis on "...useful to a society of peers and management." It is envisioned that the IAC's in ERIN will be concerned with information useful to a wide variety of users.

There will be at least one IAC for each major functional (discipline) area of earth resources information. The IAC's will be as nearly identical as feasible, taking into account the differences in form and content of the information processed by each. In this way, a modular system is achieved and internal compatibility problems are kept to a minimum. Since existing information analysis centers are quite diverse in structure and capability, it is assumed that the IAC's will be rather dissimilar at first but will grow more nearly alike through the years as common equipment, techniques and procedures are introduced.

Because of the communication network, the physical location of each I&AC is not a critical factor in system design. It should be located wherever the information, equipment and personnel required for its subject area can be most conveniently housed. In actual practice, the physical location will be influenced by historical and political considerations. A given IAC may well be housed in and operated by a governmental agency, a university or a contractor facility. The existing information analysis centers in the earth resources disciplines can be linked into a network and provide the basis for an initial system. These centers can then grow in capability and compatibility, and new IAC's can be added into the network as the need arises.

The primary functions of the IAC are to:

- o maintain the archives of fundamental data and information in a particular subject area,
- o have available, either in-house or on a consultant basis, a group of experts in the subject area for the purpose of analysis and synthesis,
- o provide sufficient computer and other processing capabilities to yield timely and useful responses to a wide variety of requests for information.

The IAC will not normally interact directly with the user, that function being relegated to the CAC. However, in cases where detailed information and analysis is needed it should be possible for the sophisticated user to consult the subject experts attached to the IAC on a direct, interactive basis.

Some IAC's will have a complex computing capability while others will use computers only for teleprocessing and communications. In those areas where computers are not widely used, staff members will perform the corresponding functions of information storage, transformation and retrieval.

In its most general form, the IAC will store information in practically every form currently in use or being developed. It will process the information in many different ways, making use of both human and machine capabilities. The information to be maintained by the IAC falls generally into the following categories:

- o language text
- o photographic imagery
- o digital data
- o physical samples (well cores, soil samples).

The two primary means of physical storage for the information will be:

- o reduced visual image (microform, laser-crystal)
- o electromagnetic storage (magnetic tape, disk, core).

The choice between these two is made on the basis of whether the material is to be used primarily by a human or by a machine. Of course, physical samples cannot themselves be reduced (at least, not by present technology) and so there must be rather severe limits placed on their number and size. However, information about the samples may occur in any of the other three forms and will be treated accordingly.

Conversion from a visual image to an electromagnetic digital representation may be made using optical character readers, optical scanners, or human interpretation and keypunching. Conversion in the other direction, from digital to graphic form, may be made using photographic techniques on any number of output devices; e.g., computer-output-microfilm (COM) which records a cathode ray tube (CRT) image on microfilm.

Various levels of processing will be applied to the information. Some information will be stored at the IAC in the same form in which it is received and then later retrieved and passed to the user with no transformation taking place. At the other extreme, some information will be highly transformed and organized prior to storage, and will be subjected to complex analysis and manipulation to arrive at an output which satisfies the user's needs. All the elements of processing-storage, transformation, organization, and retrieval may be performed at each IAC.

The IAC may be thought of as combining many of the functions normally associated with a technical library, a computation center, and a research institute. A digital computer complex will constitute the heart of the IAC since transformation of the information by computer is one of the IAC's major functions. Also, the computer's processing capability may be used to reduce the amount of information which must be stored by being able to reconstitute information upon demand. But a great deal of the text and image information will be maintained in visual form and will not normally be converted to machine-readable form since optical storage is usually more compact and much more economical. In this case only short surrogates (abstracts, index terms, etc) will be readily available for machine processing. The documents themselves (in reduced form) will then be stored and retrieved by humans or by mechanical devices under computer control.

The third role of the IAC, that of a research institute, makes use of human subject experts (scientists, technicians) who perform in-depth studies and analyses in the subject area using the information available at the IAC and then adding to its store the results of their investigations. One proposal which has been made for staffing the IAC with subject specialists would be to provide fellowships or sabbaticals for academic researchers so that they might spend a year or two in this specialized, information-rich environment and then return to their own institutions to make additional contributions to the field.

3.4.4.5 Current Awareness Center

The CAC is that part of ERIN which interacts with the general user public. The number and location of the CAC's should be determined on the basis of user accessibility and effective service. One might envision 40 to 50 essentially identical centers strategically located around the country.

The primary function of the CAC will be communication, in the broadest sense of the word. Very little processing or analysis will be performed at the CAC. The CAC performs a service function - accepting requests or queries from users, communicating the requests to the proper IAC's, then communicating the answer or response from the IAC back to the user. Since ERIN is highly interactive, continuing dialogues may be maintained until the user is satisfied.

In communicating with the IAC a variety of devices and procedures will be used. Computers will perform some pre-processing of requests and post - processing of results as well as taking care of the usual teleprocessing tasks. Printers, plotters, CRT's, teletypes and any number of other input/output (I/O) devices will be used for direct communication between the IAC computers and users or CAC staff. For non-computer communication simple vocal communicators (telephones) may be used in many cases, together with video and facsimile transmission capabilities. When a longer response time can be tolerated, physical transportation of data products by mail or similar means may be used.

Communication with the user will normally be handled by CAC staff members who will be experts at interacting with the user to be sure he obtains the information he really wants. The auxiliary functions of education and publicity will be performed by ERIA acting through the CAC's.

3.4.4.6 Summary System Concept

ERIN makes use of existing data collection agencies and existing subject-oriented information analysis centers. The acquisition and analysis functions are the responsibility of existing agencies with cognizance and expertise in the appropriate areas. The acquisition function will be expanded as necessary to insure adequate coverage of the sources of earth resources data. Processing will be performed by the IAC's, which will be upgraded and augmented to form a complete network of coordinated centers which encompasses all the major subject areas of earth resources information.

The best technology available will be used in both the IAC's and the CAC's. In the IAC's this implies (1) extensive use of visual image reduction techniques such as microfilm and the newer techniques, and (2) a highly capable computer complex which emphasizes processing speed and capability to reduce the amount of information which needs to be stored. In the CAC's, the use of the best technology implies a variety of communication and display devices so that a high degree of user interaction with the system may take place and so that the user may obtain his information in the most convenient form.

3.4.5 TRIAD-Derivative Center

TRIAD (Tellurian Resources Inventory and Development) is a conceptual design for an operational earth resources survey system [29]. Although not explicitly designed to be an information management system, TRIAD is so structured that it could easily serve that function. This section describes how TRIAD could be modified to serve as an ERISTAR system.

An operational TRIAD would consist of three major subsystems: (1) a data acquisition subsystem, (2) a data handling subsystem, and (3) an Earth Resources Survey Administration, henceforth called ERSA. These three subsystems would be housed in a single national center, located in the Washington, D. C. area.

To place the TRIAD system in the same framework as ERISTAR, it is necessary to map the three TRIAD subsystems into the four ERISTAR subsystems. The key to this mapping is TRIAD's data handling subsystem, which would perform three main functions: (1) data collection, (2) data processing and storage, and (3) data distribution. The first of these, together with the data acquisition function, form the sources subsystem functions of ERISTAR. Data processing and storage form the

processing subsystem functions, while data distribution roughly corresponds to the user subsystem functions. The ERSA function is similar to the management subsystem in ERISTAR. Exhibit 3-9 depicts this mapping. The following discussion describes a TRIAD-derivative system in the ERISTAR subsystem format, with emphasis on the processing subsystem.

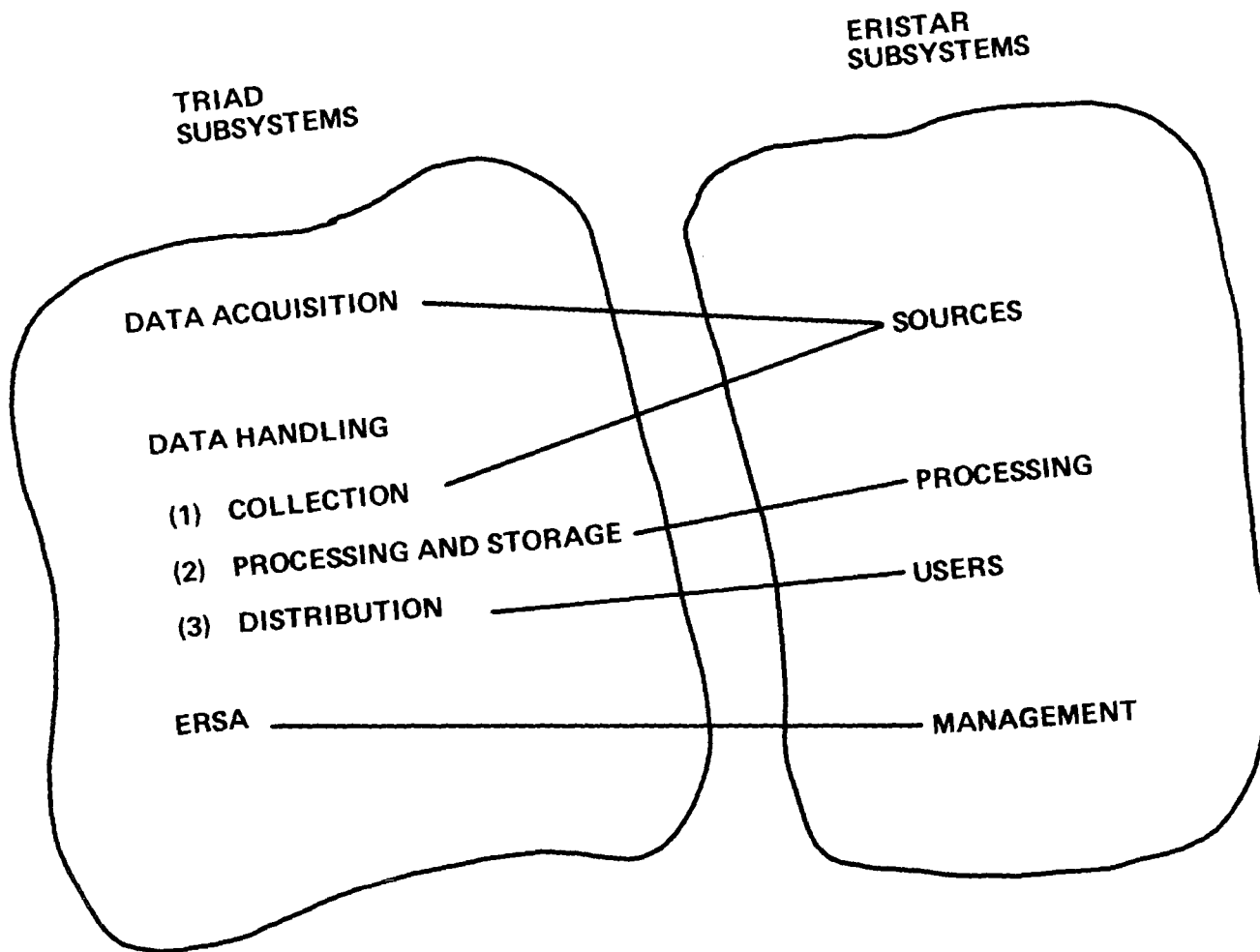
The TRIAD-derivative sources subsystem would consist of three modes of data acquisition: (1) satellite, (2) aircraft, and (3) surface, including field personnel and untended ground sensors. These acquisition sources would be tied together by a communications network which would perform some degree of pre-processing, including duplication and temporary storage. These pre-processed data then flow into the processing subsystem.

The TRIAD-derivative processing subsystem would perform the following functions:

- o Initially processing all data received, including recording, annotating, cataloging, and indexing
- o Reproducing data for storage, analysis, and further processing
- o Further processing, including image enhancement, rectification, digitizing, and gridding
- o Maintaining and administering a Working Data Bank, that is, a point at which those data with high utilization potential are deposited
- o Maintaining and administering a Permanent Data Bank, that is, a depository for all data received into the system
- o Providing any special processing requested by users
- o Coordinating among the components of the processing subsystem, all research and development activities.

The TRIAD-derivative users subsystem would handle user requests and distribute data to users. As conceived for the TRIAD system, a large volume of information would be supplied to a small community of users, primarily in government, universities, and large business firms.

The TRIAD derivative management subsystem would consist of an administration center (ERSA), which would be the hub of the entire system and house the collection, processing, and user service centers. The organization would be a completely new agency, rather than amalgamating several existing government activities.



**EXHIBIT 3-9: MAPPING THE TRIAD SUBSYSTEMS
INTO THE ERISTAR SUBSYSTEMS**

The above description of a TRIAD-derivative system attempts to adhere faithfully to the description provided in [29]. Although this description differs markedly from that which would perhaps evolve from the present design effort, it is worthwhile to establish the salient features of TRIAD in the event this type of system were elected for ERISTAR:

- o It would be a new national agency
- o It would be a highly centralized national system, with the major operations housed in a single center
- o There would exist an assortment of well organized, highly capable data sources
- o There would exist a highly capable processing technology
- o There would be a small, elite, community of users, so that the system would be rather passive in interfacing with users.

3.4.6 Advanced Network

The following is a very broad approach to the design of a very advanced system when compared to present systems. The system, shown schematically in Exhibit 3-10, should meet the following objective: "To provide any user with earth resources information and the analysis and interpretation of this information to any level he desires. The system components are described below.

3.4.6.1 System Management

The management portion of the system should encompass two main areas: (1) to oversee the operational aspects of the system and (2) to be responsible for educational programs, marketing, advertising, and promoting system products. The first function should be the responsibility of a System Internal Operation Management Office (SIOMO), while the second function should be the responsibility of the System Education and Promotion Office (SEPO). These two offices as well as all the other aspects of the system would be managed by the Earth Resources Information Agency (ERIA). This agency could be uniquely created for this purpose and be headed by a board composed of representatives from agencies such as NASA, the United States Department of Interior, the United States Department of Commerce, the Environmental Protection Agency (EPA), and others which are heavily involved in the earth resources field.

3.4.6.2 Sources

The sources portion of the system has the principal function of identifying and gathering earth resources data and submitting this data

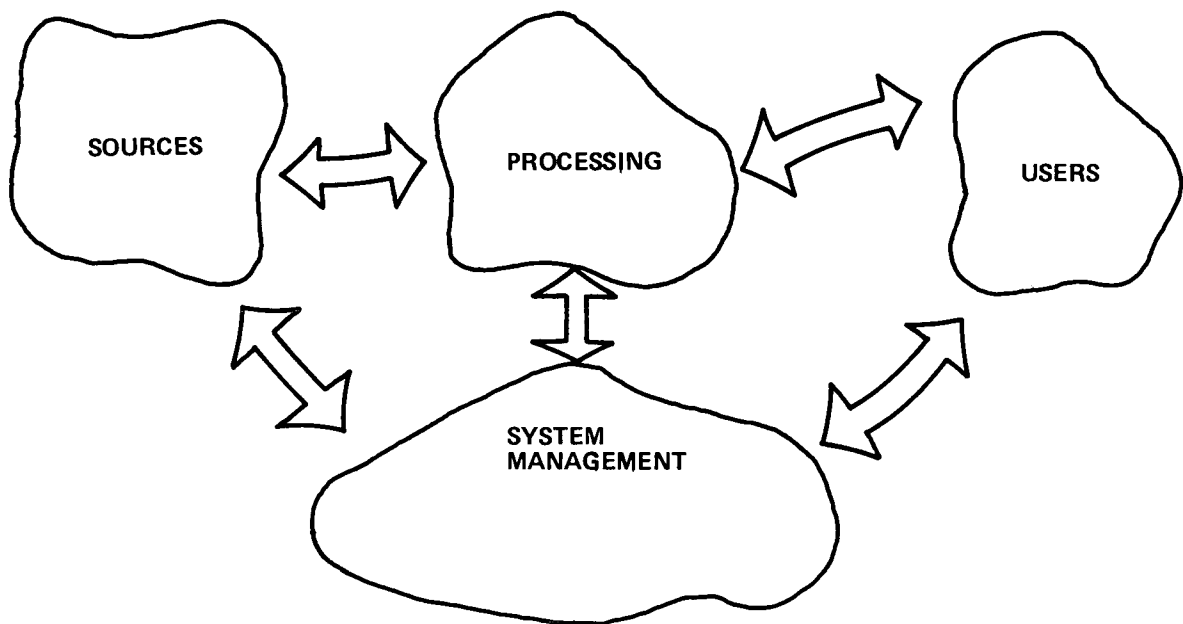


EXHIBIT 3-10: GENERAL SCHEMATIC OF SYSTEM

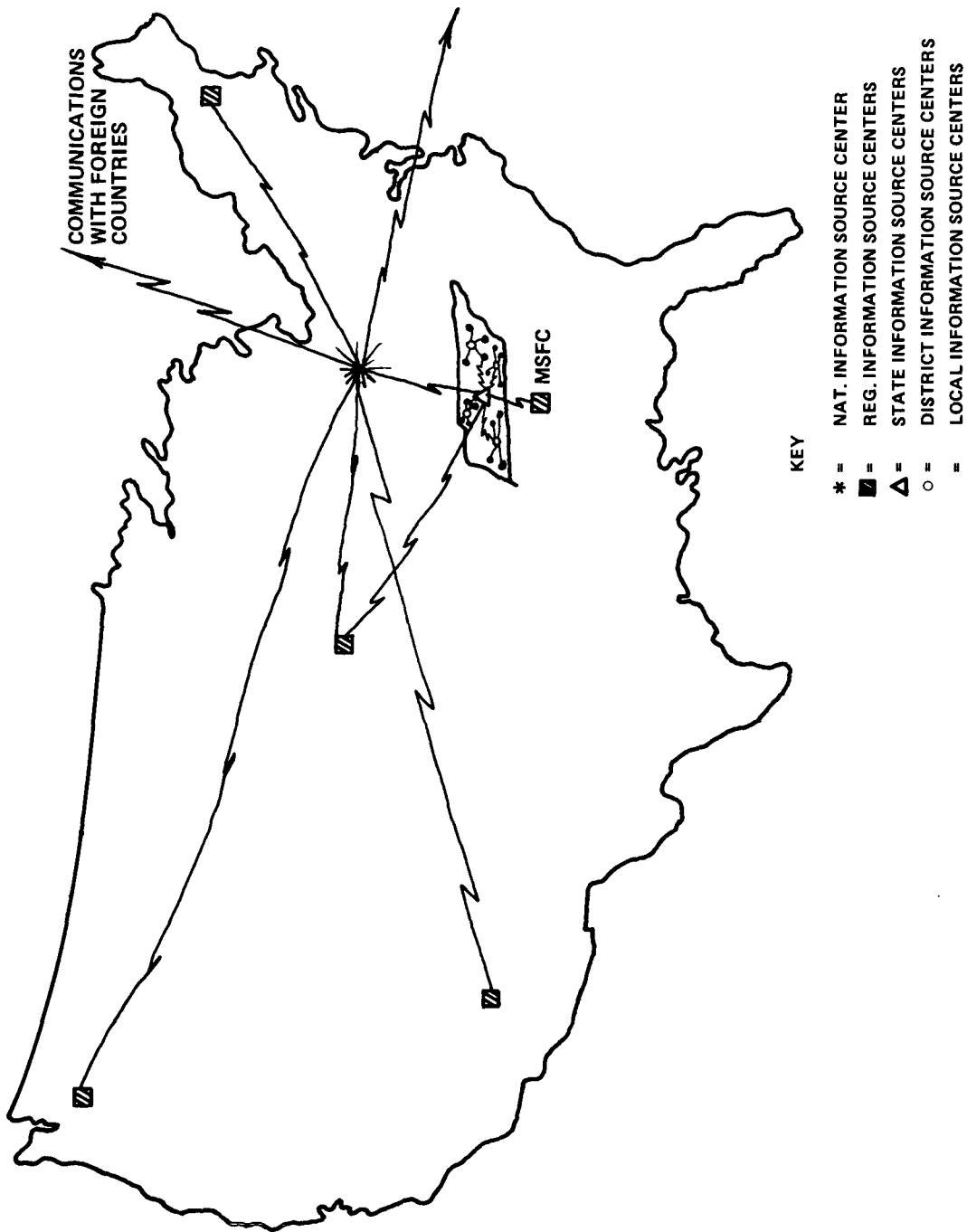


EXHIBIT 3-11: SCHEMATIC OF SOURCE COMPONENT ORGANIZATION

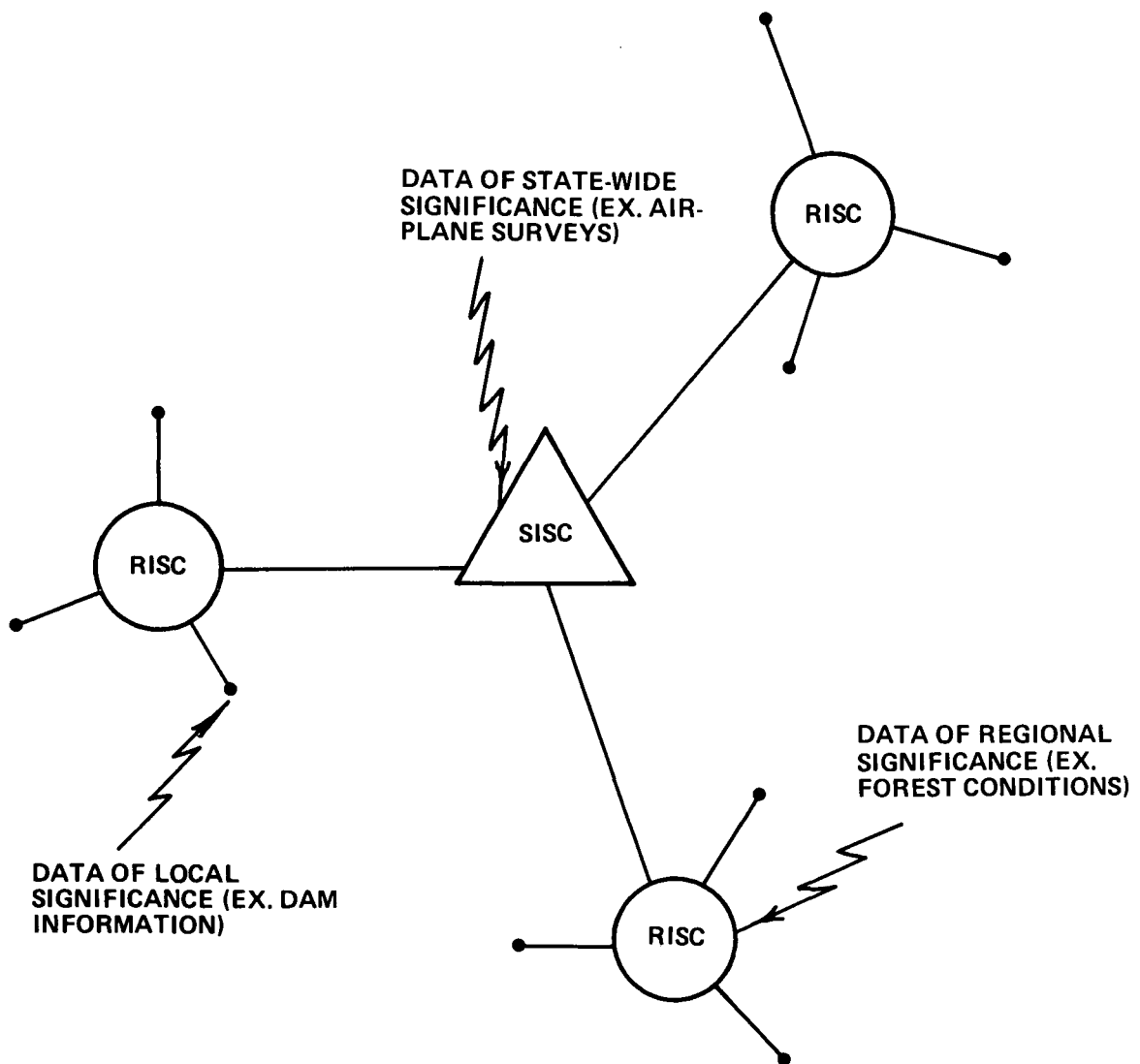


EXHIBIT 3-12: PROFILE OF STATE INFORMATION SOURCES NETWORK

for processing. In order to accomplish this objective the sources portion of the system is divided into a National Information Sources Center (NISC), several Regional Information Sources Centers (RISC), State Information Sources Centers (SISC), District Information Sources Centers (DISC), and Local Information Sources Centers (LISC). This organization is shown schematically in Exhibit 3-11. Communication with foreign countries is accomplished at the NISC level.

Each center is responsible for gathering information pertinent to its office. For example, the SISC will have the charge of collecting and organizing data at the state level. These data might include state-wide airplane surveys and studies. In addition, the SISC would coordinate the function of the RISC. A profile of the system at the state level is shown in Exhibit 3-12.

3.4.6.3 Processing

The processing function of the system consists of providing data products and information services. In order to accomplish these goals the system must perform the operations of Storage, Transformation, Organization, and Retrieval (STOR) on the data provided by the sources subsystem.

The processing function may be considered the "brain" of the system since it is capable of reacting intelligently to commands and, at the same time, performs routine functions such as keeping a distribution network operational. The following are representative approaches which will satisfy the processing subsystem operational function requirements:

- o A comprehensive mailing system.
- o An interactive document retrieval system that is not only responsive but also is capable of displaying entire documents in a variety of ways, including a screen.
- o Data enhancement. An example would be the display of a satellite picture where the user can accentuate details such as vegetation.
- o Data interpretation. Using the above example, the user should be able to ask questions such as: What percentage of the area in the photograph is covered by vegetation of a certain kind?
- o Automatic organization and storage of information. This important function deals with organizing information as it flows into the system and storing this information in appropriate locations. Due to the great amount of information that would flow into a system such as this, the organization and storage function should be essentially automatic.

- o Data Analysis. This is probably the hardest task. A truly effective data analysis system should be able to analyze data and arrive at conclusions. For example, the user might ask the system to analyze the weather and terrain conditions of a certain area and ask the system if that area is suitable for planting a particular crop. This capability requires the use of sophisticated artificial intelligence concepts which have yet to be developed.
- o Additional related processing functions.

Before proceeding with the system organization it will be instructive to give an example of a typical dialogue which the system should be able to handle. The following dialogue is between the system and a fairly inexperienced user. There is no reason to suppose that the dialogue should not be carried out in a natural spoken language. This capability should be within our reach within the next twenty years.

USER (U): sign on.

SYSTEM (S): state your needs.

U: I am interested in earth resources information.

S: What particular aspect?

U: The effect of air pollution on life expectancy.

S: Of animals or humans?

U: Humans.

S: The obvious answer is that air pollution has a detrimental effect on life expectancy. Several studies have been conducted. One meaningful approach to viewing these studies is to examine the average life expectancy in cities where pollution has been high versus cities of similar size with considerable less air pollution.

S: Would you like to see a sample of these studies?

U: Yes.

S: The following study (title, author, and other bibliographic data are given) shows that average life expectancy in Detroit, Mich. is 1.3 years less than in Miami, Florida. After human factors normalization, it concludes that the differential due to air pollution is .4 years. Would you like to read the study now?

U: No. Send a copy to (home, address given here).

S: Done. A microdot copy will be at the given address within 24 hours. Would you like to pursue this subject further?

U: Yes. Give me an analysis of the expected average decrease in life expectancy due to general pollution of the environment on a worldwide scale.

S: This analysis will require at least 10 seconds. Please be patient.

S: (Repeats: "Still working on the problem" every five seconds)

S: (After 20 seconds). Although general pollution in the United States, Canada, and several European and Latin American countries has decreased dramatically in the past 15 years, this decrease has been offset by the continued indiscriminant industrialization of other countries (a typical list is given here). The consequence on a worldwide basis is that life expectancy as related to general pollution has remained essentially the same for the past 12 years. Would you like finer detail? If so, pose specific questions.

U: No.

S: Anything else?

U: No. Sign off.

S: Please remove all trash from work area. Thank you.

Although this interaction may seem somewhat far-fetched, it is generally agreed that this capability will be entirely possible in twenty years or less.

One attractive organization for the processing subsystem is to have centralized processing centers(CPC's) which are fed by subcenters of less capability. In addition, it is conceivable that there will be many specialized processing offices which perform a limited number of services. For instance, all satellite data are better processed in one location and then distributed throughout the system. This avoids duplication of equipment and manpower.

A schematic diagram of a possible organization of the processing subsystem is shown in Exhibit 3-13. This particular organization utilizes the CPC concept supported by Auxiliary Processing Centers (APC). One way of implementing this concept is to have one CPC in every state (housed preferable in the same location as the SISC). The APC's

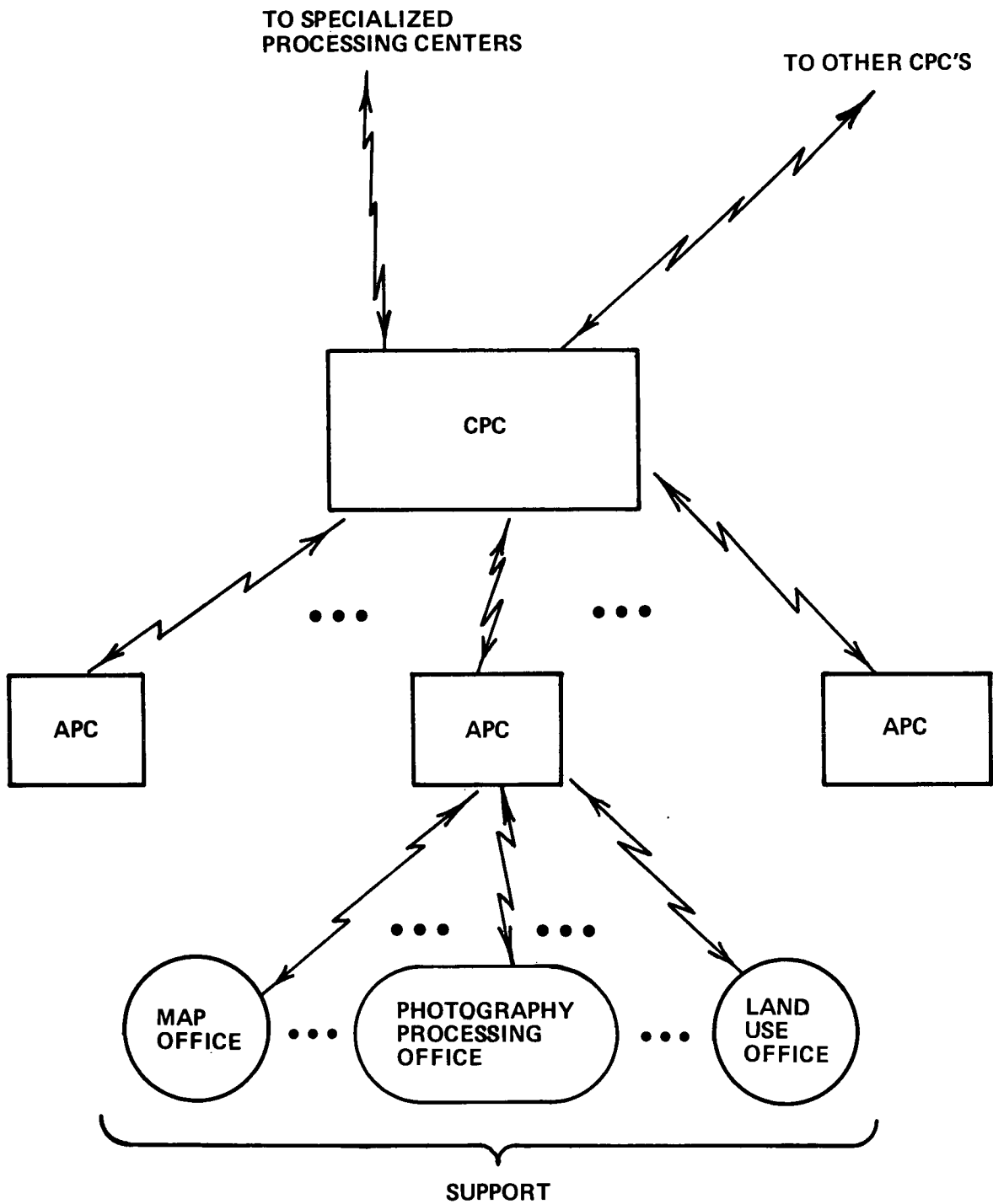


EXHIBIT 3-13: ORGANIZATION OF PROCESSING SUBSYSTEM

could be similarly housed with the RISC's. These APC's would be in turn supported by small specialized offices such as map offices, aerial photography processing offices, land-use offices.

3.4.6.4 Users

The advantage of postulating a very advanced system is that the user problem becomes less significant since, in principle, the system is capable of serving anyone within reason. Under this assumption, we may divide users into two principal categories: (1) direct users and (2) indirect users.

Direct users query the system essentially by themselves. Indirect users, on the other hand, rely on an information specialist to provide them with information. Although one could argue that this specialist is part of the system, we choose not to consider him as such. He is the interface between the system and the user that needs help. This classification is, of course, arbitrary, but it helps in classifying users into two broad categories of system competence.

The information specialist, as envisioned here, is a highly trained individual who has been educated in a discipline yet to be formulated. One can envision this discipline as being on an equal footing with professional careers such as engineering, law, and computer science.

3.5 TRADE-OFFS

Once a definitive set of alternative approaches has been delineated, it is necessary to apply the selection criteria and constraints to choose the approaches or tasks to be implemented. This activity constitutes the "trade-off" phase in the systems approach. The "trade-off" process goes as follows:

- o Any approach which violates a constraint that has been established for the system is discarded.
- o With each selection criterion, all remaining candidate approaches are compared and ranked in order of preference. After all criteria have been considered, there emerges a composite rank ordering of the feasible candidate approaches. This process might be formalized through the use of certain group ordering techniques, or it may be accomplished in less formal fashion by simply seeking agreement by the analysts. The latter is especially useful when there are only a few candidates that differ markedly with respect to the criteria.

The following sections describe the process by which a concept for a total systems approach was selected by the Information Processing task group. The key elements in this process were (1) the elimination of a national center approach, (2) the consolidation of the hierarchical network into a single approach, and (3) the selection of a time-phase implementation of three systems: the Linked Network, the Hierarchical Network, and the Advanced Network.

3.5.1 Elimination of the National Center Approach

The TRIAD-derivative system described in section 3.4.5 is essentially a national center approach for an earth resources information management system. Although its highly centralized character offers several serious drawbacks, the national center approach is nonetheless feasible by the set of constraints defined in section 3.3.1. Therefore it must be compared to the other four candidate approaches with respect to the selection criteria set forth in section 3.3.2. In this comparison, the national center approach is decidedly less attractive than any of the other four candidate systems. Principal among its deficiencies are those aspects pertaining to the user, such as user effort, interactive capability, user satisfaction, and adaptability. A serious drawback is its lack of implementability. That is, the Federal government might hesitate to invest funds into a system that requires elaborate acquisition apparatus but offers information primarily to a small, elite community of users.

Another consideration is how well the national center could evolve over time from its initial implementation to a final design form. The only route that it could take in evolving to a more capable system is to add centers in other areas, in which case it forfeits its national center character and becomes a network. The more desirable route is to establish a network initially.

The national center approach is thus discarded from further consideration in favor of a network approach. Further discussion of the national center trade-off is found in Chapter 5 below.

3.5.2 Merger of the Hierarchical and UNISTAR Network Approaches

In attempting to compare the Hierarchical Network and UNISTAR - Derivative Network approaches of sections 3.4.3 and 3.4.4 respectively, it becomes apparent that the two overlap so significantly that they could easily be consolidated to form a single approach. The Hierarchical Network plan calls for a central information analysis center at the national level, several regional centers throughout the United States, a state center in each state, and several current awareness centers throughout each state. Although the current awareness centers might specialize to some extent, the higher levels in the hierarchical structure would be largely interdisciplinary. The UNISTAR - derivative system, on the other hand, would be organized more along discipline or

functional lines. There would be a federal Earth Resources Information Agency (ERIA) for administering the system. Other federal agencies would be largely responsible for operating information analysis centers, where the major processing activity would reside. Hence, there would tend to be subject specialization in these centers. In addition, there would be a network of information dissemination centers throughout the United States, the number and location of which would be determined on the basis of user accessibility and effective service. Information acquisition would remain the responsibility of those agencies already charged with that function.

The merger of these two approaches lies in assigning the primary acquisition and processing functions to those agencies where they already exist. For convenience, one can think of an Information Analysis Center at each such agency, although the formal institution of such centers might be impractical. A hierarchical structure, with national, regional, state, and local centers, would serve the functions of administration, coordination, and dissemination. Hence, there would be the hierarchical network of centers internal to the ERISTAR system and a network of specialized Information Analysis Centers in federal, state, and private agencies external to the system.

3.5.3 The Growth Concept

The final result of the trade-off operation is a time-phased plan for implementing a network structured ERISTAR system. This multi-phase development plan incorporates the essential features of the Linked Network approach, the merged Hierarchical/UNISTAR Network approach, and the Advanced Network Approach. Hence, this plan consolidates all four of the network structured systems considered in the "approaches" phase.

Exhibit 3-14 illustrates the time-phasing of the three operational ERISTAR system designs over the period from 1973 to beyond 1985. Phase I represents a system which can be implemented immediately with minimal investment in additional resources. Phase II represents a substantial commitment to the provision of earth resources information, but requires no breakthroughs in science and technology beyond the current state-of-the-art. Phase III represents an advanced, highly capable system which will require success in several current research and development areas for its total implementation.

3.6 PLAN FOR TIME-PHASED PROCESSING SUBSYSTEM

As was mentioned in section 3.5.3 above, the merging of the system alternative approaches described in section 3.4 resulted in a time-phased plan for growth. This growth pattern is based on the capability and degree of complexity associated with each of these systems.

The most important consideration in planning for system growth is

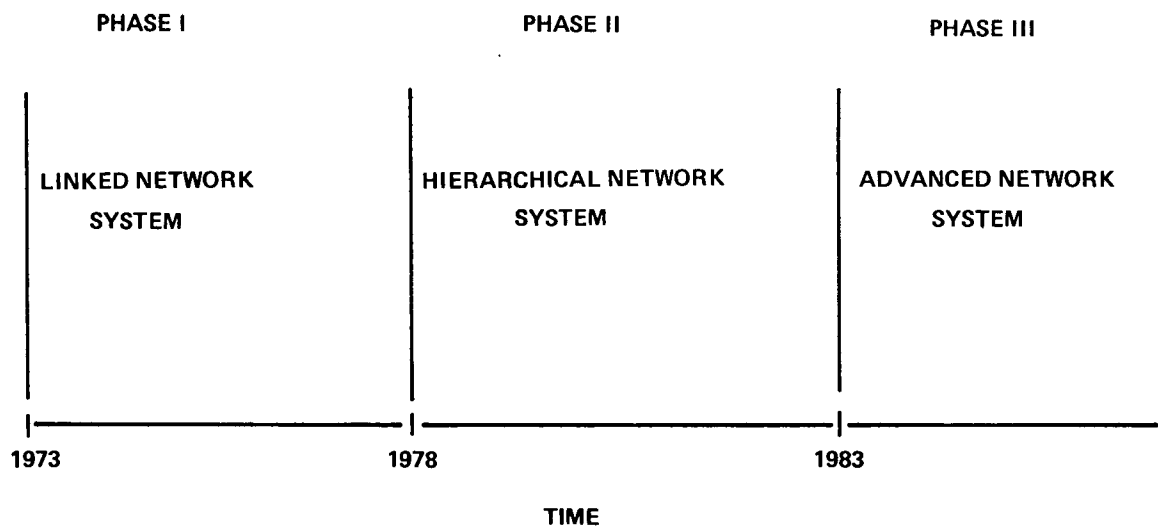


EXHIBIT 3-14: TIME - PHASED IMPLEMENTATION OF ERISTAR

probably a continuity or fluidity in the growth pattern. This can be accomplished by anticipating the fundamental structure that the system will have and planning the growth around this skeletal structure. Although this may seem an impossible task, it should be noted that there are a limited number of ways a system can be structured, regardless of its complexity. Once a certain structure is chosen and the development started, the momentum associated with any complex system will keep the basic initial structure fairly intact, as long as the growth pattern is planned around this structure.

The plan for growth in processing capability adheres to the above considerations. The growth in this area must be planned along two basic lines: (1) technological innovations, and (2) increased processing power to keep up with overall system growth. The first consideration is closely related to the system's ability to introduce innovations into its operations on a regular basis. If the system is to be current, it must keep abreast of technological developments. In terms of processing this includes the purchase on a regular basis of such things as faster and more powerful computing machines, improved optical systems, improved mass storage devices.

The second consideration simply deals with providing additional processing facilities to accommodate increased use of ERISTAR. Clearly this consideration is not independent of the first since the purchase of new equipment should be guided by research on the characteristics of what is available on the market. This also incorporates the notion of growth with regard to the number of centers and sources for ERISTAR.

As was indicated in Exhibit 3-14, the planned time span for the system to grow from its simplest form to a fairly complete operational system is approximately ten years. This time span is intended to represent an average estimate which was calculated on the basis of a national commitment to proceed with the development of ERISTAR. Clearly the time for any phase can be decreased (up to a point) as a function of the effort dedicated to the task. The time spans shown in Exhibit 3-14 take this into account by recognizing that there must be a certain cost-effective amount of time lag between a plan to proceed and the actual implementation of the system.

3.7 CONCLUSIONS

This chapter has dealt with the concepts underlying the processing subsystem of ERISTAR. The objective, requirements, and constraints and criteria have been defined. In addition, five basic alternative designs of complete systems were discussed in an effort to better define the processing requirements which must be a part of the final system. As it turned out, the merging of the ideas present in these five designs into a time-phased plan provided a very significant input to the total group's final system design. The plan for the ERISTAR processing subsystem is discussed in chapter 6, section 6.2.3.2,

below. This plan is presented in terms of the information processing functions that will be ongoing in a typical ERISTAR center, and in terms of the personnel that will be required to handle those functions. The relationship of the ERISTAR processing subsystem to other information processing activities occurring outside the realm of the ERISTAR system is discussed in Chapter 6, section 6.2.2.

An attempt has been made in this chapter to provide a flexible framework which will serve as the basis for a more detailed system design and, hopefully, for a working system. It should be kept in mind that the principal aim of this work has been to consider the fundamental processing requirements and considerations which must be a part of any successful earth resources information management system although wherever possible, detailed descriptions have been provided. The importance of these basic considerations is emphasized by taking a cursory look at many of our present information systems whose unplanned growth has resulted in seriously deteriorated service to the users.

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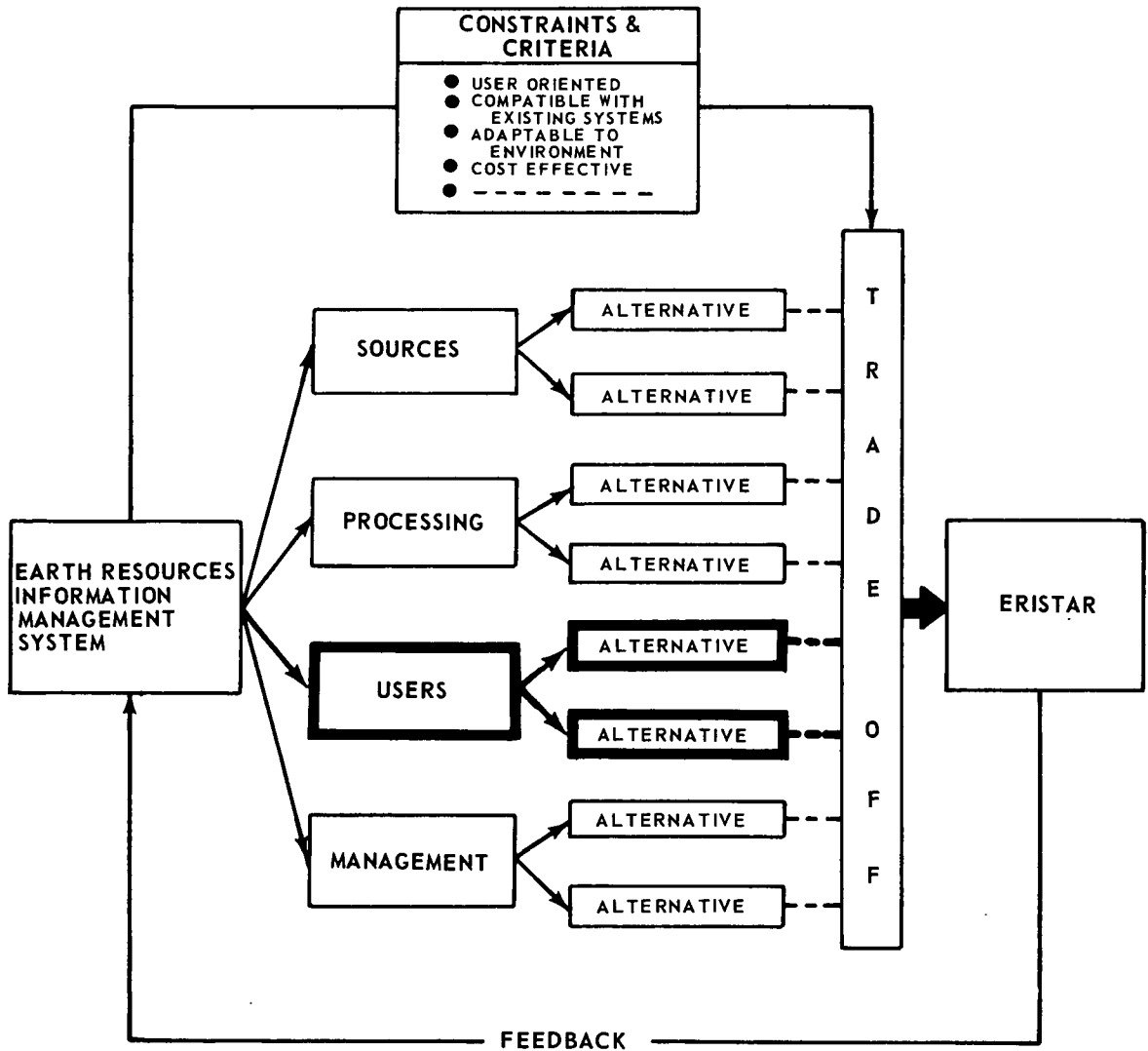
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4. USERS



4.1 INTRODUCTION

The User-Services Division in ERISTAR is the result of an application of the systems approach to increasingly detailed levels of decision-making. Beginning with the general system specifications displayed in Exhibit 4-1 and proceeding through several trade-off iterations, the resultant User Task Group recommendations are inferred in Exhibit 4-2.

The information explosion and the attendant problems are well recognized and have been documented in reports by agencies such as SATCOM and COSATI. Society's need for access to and effective utilization of Earth Resource data and information to solve its environmental problems is a specific example of the general information problem. A proposed solution to this general problem has been to develop and implement the concept of Information Systems. This includes organizations such as specialized Information Analysis Centers and Retrieval Systems.

A successful information system is one that is used by the audience/group for which it was designed. This implies that the systems designers familiarize themselves with the needs of the user community so that the information system installed provides a satisfactory service.

Historically, information systems have not attained a high level of user acceptance. It follows, therefore, that most information systems have not reached a high level of utilization. A low level of system usage can be generally attributed to a failure to satisfy the user needs. Specifically, these failures can be categorized as dissatisfaction with either the system output or the level of service rendered by the system. User dissatisfaction with the system output is related to informational content, level of detail, terminology used, format (arrangement) and display media. System service is judged by ease of use, convenience or accessibility and response time.

Much of the inferred difficulty can be assigned to a lack of communication between the design group and the user community before the system was designed. The resultant situation can be described as "a grand solution looking for a problem". A possible reason for this dilemma was stated in the editorial column in Business Automation:

"Unfortunately, many decision-makers felt that once they had a computer they had a system. Many users have learned the hard and expensive way that "Machines do not a system make." Machines are the tools to implement the system, and never before has such a powerful array of tools been available with which to design and build a system." [1]

Because of the glamour of the new hardware and new processing techniques, decision-makers tended to underestimate the problem of satisfying the user of the system. An interesting analysis of this problem was developed by A. M. Katz [2]. It is displayed as Exhibit 4-3. The technique

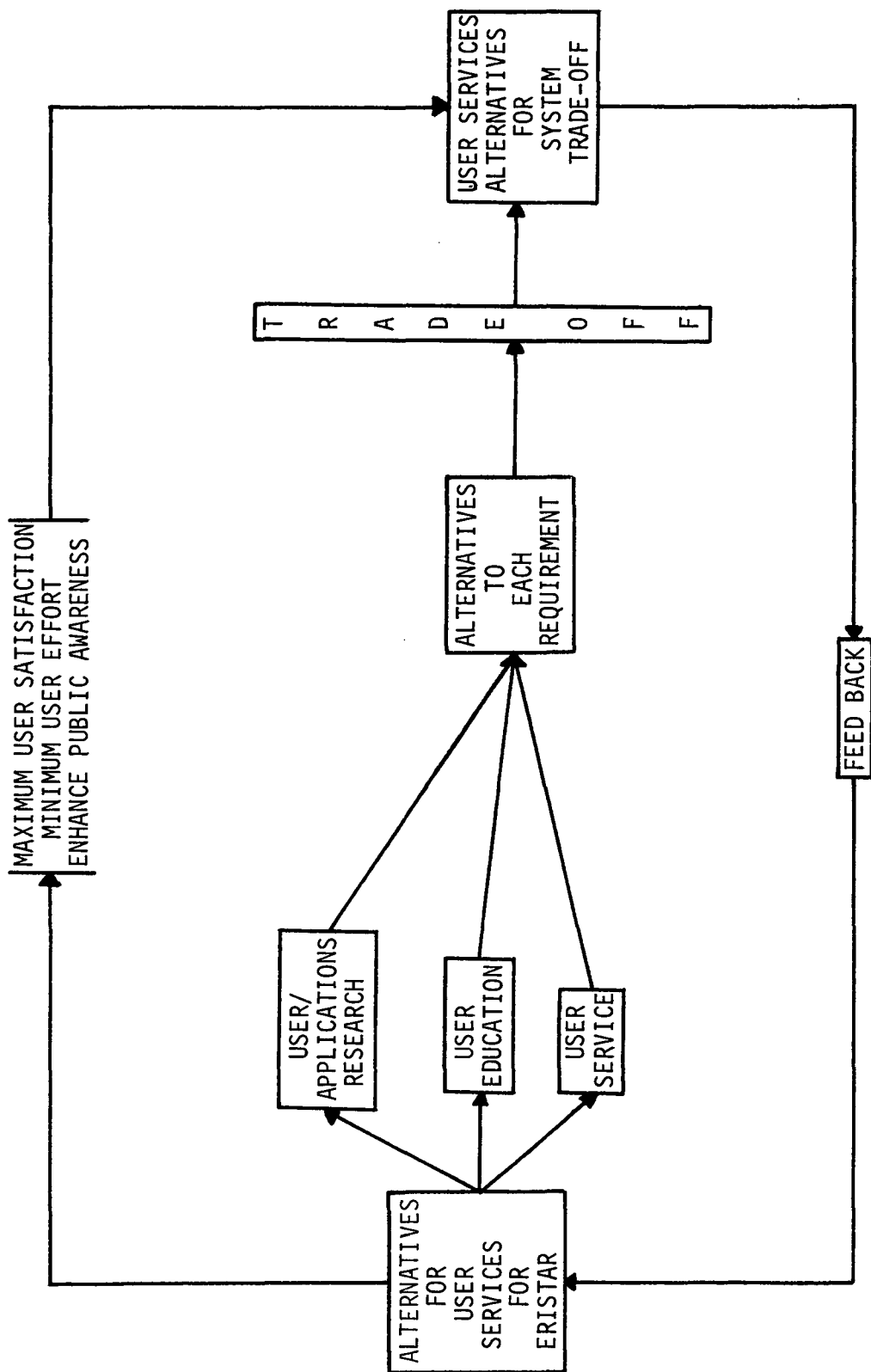


EXHIBIT 4-2: USER SERVICES SYSTEM CHART

COMPONENTS SUB- SYSTEMS	HARDWARE	TECHNIQUES	PEOPLE *(SYSTEMS STAFF)	ORGAN- IZATION * (USERS)
COLLECTION				
DATA PROCESSING				
ANALYSIS				
PRESENTATION AND DISSEMINATION				

DEGREE OF EMPHASIS PROPORTIONAL TO INTENSITY OF SHADING

*ADDED BY ERISTAR DESIGN GROUP

RELATING ERISTAR SUBSYSTEMS
TO EMPHASIS CHART

COMP. S.S.	HDWR.	TECH.	PEOP.	ORG.
COLL				
D.P.				
ANAL.				
DISS.				

EXHIBIT4-3: GRAPHIC DEMONSTRATION OF EMPHASIS PLACEMENT IN THE DEVELOPMENT OF INFORMATION SYSTEMS (5)

of coloration density (cross-hatching) utilized in the chart indicates the relative emphasis placed on the various elements of an information system. This emphasis reflects the ultimate allocation of resources to develop each of the requisite subsystems.

The ERISTAR concept of the User Subsystem places it approximately in the lower right hand quadrant of the chart. It will be noted that the average emphasis in this area is quite low (sparsely cross-hatched). In particular the lower right hand cell which could be labelled "Systems Output Dissemination To The User" is practically blank. This is symptomatic of the benign neglect typically afforded this area to date. It does not evidence a real concern for rendering service to the user. Consequently the reader can find repeated statements of the type listed below from the UNISTAR Report:

"Many processing systems today are failures because they fail to satisfy the user."

"Existing systems and organizations have tended to concentrate on the source end of the stream...."

"There is a concern that the user community be identified. No IMS can be effective if it is not aware of the make-up of its users." [3]

This behavior pattern is characteristic of many previous attempts to develop Information Systems. An assessment of the available literature, and remarks of a series of guest speakers, indicates a unanimous or universal recognition of the most significant problem in the design of information systems:

It is necessary to gain an understanding of the users' needs before a successful system can be designed.

Consequently the User Task Group decided that a User Services Division was necessary to achieve a high degree of user satisfaction and thus insure a successful Earth Resources Information System--ERISTAR.

4.2 USER SERVICES FUNCTIONS

The User Services Division in ERISTAR will be structured and staffed to satisfy the selected criteria of:

- MAXIMUM USER SATISFACTION
- MINIMUM USER EFFORT
- ENHANCE PUBLIC AWARENESS
- MAXIMUM ADAPTABILITY.

The division will be made up of three departments, organized on a functional basis. The departments are:

- USER/APPLICATIONS RESEARCH
- USER EDUCATION
- USER SERVICE.

The basic objectives assigned to the departments in the division and the specialized skills required are displayed in Exhibit 4-4 User Service Functions. Each of the departments will be described in succeeding sections.

4.2.1 User/Applications Research

The User/Application Research (U/AR) Department of the User Services Division shall be assigned the task of determining the information needs for:

- developing new user/applications areas,
- extending new applications to existing users,
- changing patterns of use, and
- enhancing the utility of the system.

Specifically, the User/Applications Research Department will be charged with identifying the members of potential user communities and specifying system output criteria (content, format, display media, response time, etc.,) to satisfy the users needs. This is a complex task due to the wide range of user/application areas. The diversity of the User's needs has been demonstrated by special study groups attempting to bring order to the chaos by developing classification and summarizing techniques. Appendix C-1 shows the results of work by two groups. [4,5]

The research function is necessary because ERISTAR, as an integral part of an Information System, must be a dynamic organization. It must be

	USER/APPLICATIONS RESEARCH	USER EDUCATION	USER SERVICE
OBJECTIVES	<ul style="list-style-type: none"> IDENTIFY USER COMMUNITIES SPECIFY PRODUCTS FOR DEVELOPMENT CLASSIFY USERS AND APPLICATIONS IDENTIFY USER NEEDS AND REQUIREMENTS DETERMINE USER CAPABILITIES 	<ul style="list-style-type: none"> CREATE ERISTAR AWARENESS EDUCATE THE COMMUNITY ERISTAR SYSTEM EARTH RESOURCES POTENTIAL APPLICATIONS TRAIN USERS TOOLS TECHNIQUES 	<ul style="list-style-type: none"> ANALYZE INQUIRIES TO DETERMINE INFORMATION REQ'D DATA SOURCE REQ'D CENTER ACTION REFERRAL DELIVERY LEVEL OF SERVICE REQUIRED PRIORITY COMPLEXITY DISTRIBUTE PRODUCT COMMUNICATIONS
JOB TITLES	<ul style="list-style-type: none"> USER RESEARCH ANALYST 	<ul style="list-style-type: none"> EDUCATION SPECIALIST TRAINING SPECIALIST PUBLIC RELATIONS REPRESENTATIVE 	<ul style="list-style-type: none"> USER INQUIRY ANALYST USER INQUIRY CLERK USER SERVICE REPR.

EXHIBIT 4-4: USER SERVICES FUNCTIONS

adaptable and evolutionary. ERISTAR must respond to changes in the system environment due to the development of new technologies, the recognition of new problems, and the emergence of new users. The response will take the form of an implementation of new subsystems each with its own unique information requirements, data sources and processing requirements. As a consequence information systems design will be an on-going activity of ERISTAR.

The Battelle Memorial Institute report to the Tripartite Committee in 1969 concerning a United Engineering Information Service states that one of the UEIS missions should be "continuing analysis of user needs". Referring to Department of Defense studies made by the Auerbach Corporation and North American Aviation the Battelle report notes:

"Although a major user-needs study in the area of applied science and technology has been conducted, no continuing effort has been made to measure the changing use habits and information/data requirements. There is much evidence to indicate that the evolving patterns of information/data sources and handling techniques may well change the way individuals use such resources. A new generation will be filling professional roles and bringing with it a better understanding of the capabilities of computers than ever witnessed before. Where communicating with a computer has been a novelty to many in the past, it will be commonplace to the next generation.

On a more current level, there have been many new sources and services initiated since the major Department of Defense user study, and the impact of those changes has not been measured.

There seems to be little choice but to recognize the study of user needs as a continuing requirement. It should, perhaps, be viewed as a monitoring function rather than as a series of studies with definite termination dates." [6]

The User/Applications Research Staff is the group which will perform the system analysis necessary to design a system which will satisfy the user's needs when it is implemented. In effect they will define the problem so that a solution can be developed.

Action by the User/Applications Research Staff will be triggered as a result of interfaces with the user community by other functional areas of the User Services Division. In the course of day to day operations, User Service and User Education personnel will contact current users whose information needs have changed or potential users with needs which the original system did not anticipate. When this situation arises and points to a widespread need, the staff will conduct a user survey to gather and summarize the data required to define the problem.

In this survey, the potential users are identified so that they may be contacted with respect to their needs. This contact may be in the form of an interview, a telephone survey, a questionnaire, panel discussion or symposia. (Appendix C-2 provides an interesting insight into this aspect of problem definition.)

The purpose of the personal contact is to enable the user research analyst to understand the problems of the users. Ideally, the user research analysts will literally live with the users as they perform their job functions.

The information collected will be answers to the following general questions:

1. What do you do? (Job description)
2. When do you perform your function? (Scheduled by day, week, hour, etc. or on demand).
3. How do you perform your function?
4. What are the time constraints? How soon must you respond to a demand?
5. What are the tools of the trade? (Catalogs, Maps, Reference Libraries, Magazines, etc.).
6. With respect to #5 above, what preference do you have concerning the information content, format (arrangement or display), level of detail and terminology used?
7. What difficulties do you encounter in performing your function? Alternatively, are there any shortcomings in your current sources of information?
8. Why do you react or perform in the manner described? (Legal requirements, protocol, etc.)
9. What would you like to have done or have provided to enable you to do a better job...up-to-date maps, easier lines of communication?

With the completion of the survey, the resultant summary of the data collected from several users in the same classification, e.g., county agents in corn producing areas concerned with tracking the spread of corn blight, will be used by the Information Analysis and Processing Staff to design a satisfactory subsystem. This will include specifying sources of information, communication links, etc. During the design phase there will be much interaction between the user research analyst, the Information Analysis and Processing Staff (IA & P) and the potential users at critical decision points.

Upon completion of the subsystem design by the IA & P Staff, the U/AR Staff will contact the users surveyed. Essentially, this contact will be a presentation of the subsystem design to ascertain that the proposed system output information can be used and that the user understand his responsibilities. This provides a feedback loop whereby changes can be suggested before an elaborate but dysfunctional system design is implemented. When the inevitable trade-offs have been made, the modified design will be implemented. Implementation can be performed either by ERISTAR agency personnel or an external cooperating agency such as the Dept. of the Interior. Other possibilities include the use of consultants.

The primary activities of the User/Applications Research Department will be performed by a user research analyst (URA). For a preliminary job description of a URA refer to Appendix C-3.

The role of the URA is relatively straight forward. However, the importance of this role cannot be stressed too heavily. Historically, Information Systems per-se have not reached the levels of achievement or acceptance implicit in their design and promotion. In large part, this singular lack of success has been attributed to the fact that the system users were not contacted prior to and during the system design. The URA will be the interface between the designers of the system and the system users. In this capacity he will act as the "users advocate" and provide the feed-back linkage which will assure long-run system acceptability.

4.2.2 User Education

One of the prime requirements of ERISTAR is to satisfy the needs of the user. To accomplish this, the user must be aware of ERISTAR and instructed in regard to ERISTAR. Therefore, the education unit of ERISTAR has the following three major functions:

- Create public awareness
- Instruct the user
- Train the user.

It will be the policy of the User Service Division to utilize established education and media facilities whenever it is feasible.

Before a person can become a user of any system he must be made aware of the system's existence and of the services it has to offer. Even if he does not use the system, he should appreciate the benefits he receives indirectly as the system is used by others. These tasks fall in the area of public relations.

With the characteristic dynamism of earth resources information, the need for relating the services of an information system with users and

potential users has become increasingly recognized. ERISTAR offers the public relations arm of service to extend into and interface with the user communities. The public relations activities facilitate the development of and maintain a "good public image" as ERISTAR evolves in response to environmental change.

One of the more important activities of the public relations services is to create an awareness of the ERISTAR System. Only when the user community is aware of the system and makes information demands of it, will the system be useful. Creating awareness of ERISTAR will be directed to business enterprises, educational institutions, governmental agencies and ultimately to the individual.

The extent of Public Relations coverage may be geographic and by discipline. The ERISTAR System lends itself toward very broad general subject coverage over large geographic areas and yet maintains service related to specific subjects in limited localized areas.

The public relations services will attempt to stimulate earth resources information awareness by directing persuasive communications to the potential users. Persuasive communication proceeds by first determining potential users, media channels, message, and finally the source effect. The instruments of creating awareness - advertising, personal communications, promotion, and publicity -- have separate and overlapping capabilities. Their effective coordination is facilitated by the goals of the User Services Division in the ERISTAR System which is to provide optimal service to the user.

Once the public becomes aware of ERISTAR, individuals and groups will become general users. To do this they must be instructed or educated in more detail than they received from the public awareness. The following questions will need to be answered:

- What type of information is available?
- How may the information be obtained?
- What interpretative services are available?

The preparation of materials will be the task of the educational unit. The distribution of this material will be done by the public relations representative, user inquiry clerk, user inquiry analyst, and user service representative. The material to be prepared will include brochures and visual aids such as slides, films, video tape, etc.

Users of ERISTAR will have various levels of expertise in hardware components, software components, and interpretative ability. It will be the task of the User Education Department to train users.

In order to accomplish these objectives an educational system must be developed; a knowledge of the system output must be obtained; and, a knowledge of system components must be specified. The educational system must distribute to present and future users knowledge of the ERISTAR output and how to obtain this output. This knowledge can be distributed through the present educational system or through a specialized educational system. The present educational system would include universities, colleges, high schools or training institutes. A specialized educational system could be developed to handle only the training of ERISTAR users.

Training the user to use system output requires that the user know how to interpret the output and how to apply or use this knowledge. For example, the user will have to be trained to interpret the coding of the land use map generated by the computer. He will also be trained as to what information a land use map contains and the applications for which this information can be used.

The ERISTAR user will be able to obtain the system output through a variety of system components. This will require training in the following areas:

- Hardware components such as microfiche readers and computer terminals,
- Software components such as programmed interrogation procedures, canned programs, and job control language,
- Hard copy reference components such as thesaurie specification manuals and personnel directories,
- Source personnel components such as librarians, information specialists, and ERISTAR specialists.

To accomplish the training function, teaching outlines, teaching material, and teaching methods must be developed or selected. These outlines, materials and methods will be different for each hardware component, software component, hard copy reference component, source personnel component, system output, and education distribution media. To develop the training function, lists of the above components will have to be supplied by the processing, source, management and user functions.

4.2.3 User Service

A user, contacting the ERISTAR center, may have only a vague idea of the service he can obtain. On the other hand, depending upon his level of knowledge about ERISTAR services and his capabilities in transforming these services toward satisfying his needs, he may know exactly what he seeks. The user service function must deal with this entire range of user capabilities.

In the early stages of development of ERISTAR, many users may be seeking information related to problems they understand. Proper analysis of these problems by center personnel determines the types of information required, the sources to be utilized, appropriate output formats, and distribution modes. Further, decisions can be made as to the required actions to be taken within the center consistent with operating policy and procedure, but these actions may be customized to some degree.

It may be in the best interests of the user to refer him to an external source. The user makes this decision, which is a function of his cost, time, convenience, and the current capability of the ERISTAR system. It is anticipated that as ERISTAR matures, the ability to obtain information from external sources through ERISTAR will be more cost effective for him. Alternatively, it may be that the desired information requires a rather routine center action and immediate delivery.

Another dimension in handling user inquiries is determining a satisfactory "level of service." This implies that more complex attempts to arrive at solutions may take more time and resources and therefore be priced accordingly. An example would be the use of a simulation model, with various inputs to determine which sources best fit the model. At the other extreme, a routine request which has no immediate time requirement may be allotted a low handling priority to minimize its cost. Thus, level of service is intended to reflect the ability of the ERISTAR system to be flexible and responsive to the user demands placed upon it. Certain priorities may have to limit some request, but these are not intended to restrict the system in its growth goal of providing optimal service to the user community.

The role of the ERISTAR System is completed only when the desired data/information in useable formats is distributed through appropriate channels to the user. The distribution channels of ERISTAR are structured to effectively utilize those existing source agencies through autonomous actions with the user, or to coordinate the distribution through a working network relationship with the system.

The broad range of user problems and user capabilities dictates broad capabilities among the user services personnel. The more routine matters may be handled by user inquiry clerks, with the more complex situations being handled by user inquiry analysts. The educational and skill requirements will vary accordingly. The user service representative handles the distribution aspects. (For preliminary job descriptions, see Appendix C-3)

The following section discusses an active example within the User Service Department and should provide insight into the tasks performed and the skills utilized by ERISTAR personnel.

4.3 ILLUSTRATIVE EXAMPLE - A CASE STUDY

This section will first present an actual case study, dealing with the problem of acquiring adequate information to aid in making a decision concerning the feasibility of a business venture. How this same problem might be handled in a typical ERISTAR Center will then be developed. The objective of this approach is to develop an awareness of the nature of problems dealing with earth resource information and also to discuss the interactions within the conceptual ERISTAR Center.

4.3.1 Traditional Information Gathering

An independent businessman, from Mobile, Alabama, upon learning in a casual way of a local restaurant's difficulty in maintaining an adequate supply of catfish, decided to investigate the feasibility of entering into "catfish farming". He began by reading all the available material in typical agricultural magazines and trade journals. This preliminary gathering of information was encouraging enough to foster continuation of the search. Then he contacted his local county extension agent. Questions arose, for example, about the type of fish he should consider. The agent knew of some extensive activity in the State of Arkansas, so he referred the businessman to a county agent in that state. Contact with this agent resulted in a referral to the Fisheries Department of the Arkansas State Experimental Station. In discussing the problem with an expert, a species was suggested. But, for the source of this species, referral was made to the State of Washington. The basis for this decision was the similarity of the natural resources and eating preferences of the proposed area and that of Washington. The contact in Washington verified the species suggested by the expert in Arkansas and indicated sources in Washington, but was aware of the same species source in Arkansas, so referred the businessman back to Arkansas.

Next the problem of constructing the physical facilities, essentially a series of ponds, was considered. Contact was made with the Soil Conservation Office. After discussing the problem, the businessman was referred to the regional office of the Soil Conservation Service located in South Carolina. This source was successful in providing the necessary information.

Having resolved the variety of fish to raise and how to construct the facilities necessary, the businessman turned his attention to the required management practices. He contacted the Fisheries Department at Auburn University, the land-grant university in Alabama. Again he received much information including a feeding schedule, similar in its phases to the raising of beef. He was referred to mills in his area capable of generating his required feed formulas over these phases. Additional information as to the harvesting aspects were also obtained from Auburn University.

Parallel with the process of gathering the technical information he needed, the decision maker was gathering economic data concerning expected costs and incomes. Naturally, based upon his own situation as he envisioned the problem at any stage, he could exercise the option of gathering more information and refining the problem, or he could abandon it. It is important to note that this decision hinged upon information.

The process described above took several months and required considerable effort on the part of the businessman. Letter writing, phone calls, travel time, and encountering the normal delays in answers to letters, contributed to the difficulties encountered. It is this sort of experience that often forces weaker men to abandon an otherwise sound course. Perhaps the persistence and determination required to follow through is one of the differences between an entrepreneur and those who prefer better defined work, but recognition of this should not be a reason for perpetuation of a poor "system". Based on all the information he had assimilated, the businessman made a decision to enter into catfish farming. This decision obviously contains an element of risk not unrelated to the validity and completeness of the information sources he had pursued.

4.3.2 ERISTAR Information Gathering

Assume that the businessman described above had made his casual observation about the need for catfish. Further, assume he had been made aware of an ERISTAR Center dealing in information concerning earth resources. He brings his inquiry to the Center, thus becoming a potential user.

The user inquiry clerk is the contact person he first encounters. The general statement of "needing information on catfish farming" is realized to be too general, so further interviewing is required. This results in determining that essentially the user is seeking general information at this stage in his understanding of his problem. The user inquiry clerk could offer the following alternatives:

- furnish him the names of the agencies where he may find bits and pieces of the types of information which should assist him, leaving the procurement of same to him.
- refer him to the user inquiry analyst, who would further discuss his problem and hopefully be able to arrive at a proposal specifically designed to his needs.

If the user selects the first, he leaves ERISTAR for the time being, free to return later. Assume he selects to interact with the user inquiry analyst. After discussion, the analyst realizes that the problem requires further analysis. He could diagram the problem at this early stage as in Exhibit 4-5.

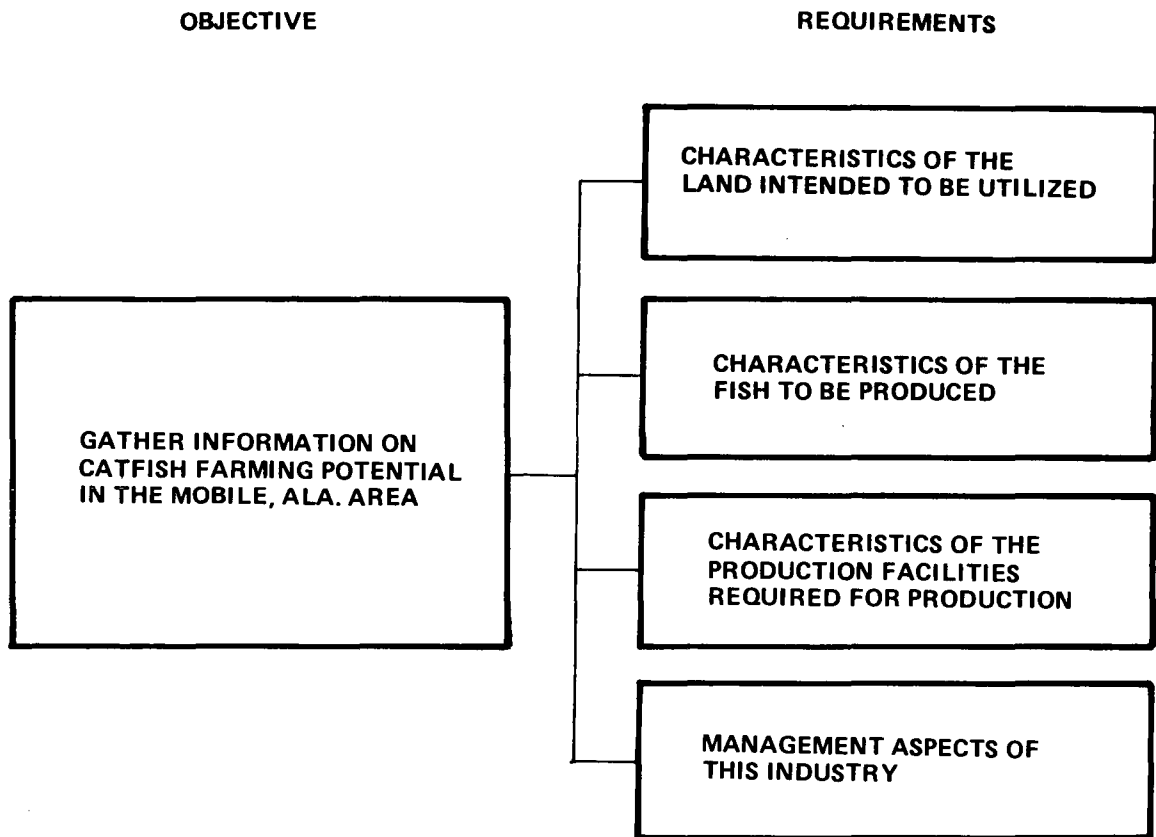


EXHIBIT 4-5: INITIAL ANALYSIS OF CASE STUDY

Since the analyst has had experience with information as a product, and is aware of many sources, he initially "shotguns" the problem with the intent of identifying as many sources as possible. First, as the land to be used is owned by the user, he suggests that as many of its characteristics as possible be determined. Two sources come to mind, namely, the Geological Survey of Alabama and the Soil Conservation Service. From the first he realizes that the following types of information may be obtained:

- ° Topology
- ° Rock type
- ° Permeability
- ° Flooding potential
- ° Flow of water
- ° Water quality
- ° Hazard potential due to faults and earthquake activity.

From the Soil Conservation Service, he can obtain the soil type classifications. (In fact, one source may overlap the other, but at this stage identification is the objective).

With respect to the fish species, the Department of Fisheries, Auburn University, is indicated as a potential source. Additionally, the agricultural economist comes to mind as a source of market information in this area. Continuing the analysis to the physical characteristics of any ponds to be constructed, the information required may be obtained from a variety of sources, such as the Geological Survey, Soil Conservation Service and local construction firms. Since the area is coastal, perhaps the Alabama Marine Environmental Sciences Consortium should also be contacted.

In the area of management aspects, the Alabama Development Office is suggested as a contact for possible information on qualifying for financial assistance. The State Environmental Protection Agency would be a necessary point to contact for any required permits and possible environmental hazards which this new industry may pose. In day-to-day operations, the Alabama Fisheries and Wildlife Department may have useful information. Possible diseases and their effects on fish may be obtained from the Oak Ridge National Laboratories, Environmental Information Systems Office.

The above discussion assumes a knowledgeable analyst, but with adequate training and organization, it is not too much to expect this level of capability. Important to note is the amount of potential information

the user is exposed to in a short time. Having established this comparison of time, discussion of the case can be terminated.

A few general comments regarding other activity within the ERISTAR Center follow:

- The analyst may use a variety of catalogs and cross references during his analysis. These may indicate sources beyond his recall.
- The analyst may indicate what further action is possible. This would include discussion of pricing, types of format for the information, when it would be available, and how to deliver it to the user. Essentially, he proposes a package.
- Based upon the information obtained in the initial search, the analyst may seek the advice of personnel in the Information Analysis and Processing Department of the Center. The complexity of the data and the sophistication sought play a large role in this decision.

The degree to which the businessman would use the services of the Center is, of course, his decision to make. The thoroughness of that service, its cost, and its timeliness determine its utility. An on-going center, with some operational experience should be quite capable of handling the type of case which has been described. Such is the challenge of ERISTAR.

4.4 EVOLUTION OF THE DESIGN

This section will present chronologically the thought process used by the User Task Group. Emphasis will be placed on presenting exhibits which summarize the detailed alternatives and approaches considered before arriving at a final design concept. Concurrently, the required redefinitions and refinements as the group progressed will be noted. The objective of this section is to give insight to the dynamic nature of the systems design technique.

4.4.1 Phase One

The User Task Group was one of the three primary task groups formed by the Auburn Design Group. Following the systems approach the User Task Group developed an objective, the requirements to meet the objective and the alternative approaches to accomplishing these requirements. The following objective was established:

to design an information/data distribution network for the users.

To accomplish this objective the following requirements were established:

- Identify users or user questions.
- Determine user needs/wants.
- Develop an information dissemination mechanism.

The results of these efforts are illustrated in Exhibit 4-6.

As a result of trying to further define the requirements and approaches, Exhibits 4-7 and 4-8 were developed. Exhibit 4-7 illustrates the attempts of the user task group to develop methods of classifying users inquiries by discipline, degree of processing and management level. Exhibit 4-8 illustrates the information dissemination by channel, class, use, format and user.

Efforts to define the user resulted in the following definition:

the entity who/which anticipates an improvement in behavior or status as a result of utilizing earth resources data.

To determine the needs and wants of the user the following approaches were considered:

- Discussion of problem among task group members
- Interviewing user where he is
- Call user to us to interview
- Poll user by mailout questionnaire
- Library research for pertinent reports and documents.

To accomplish the above, preliminary models of questionnaires and a list of potential users to be contacted were developed. At this stage the User's Task Group was ready to gather information concerning the user community identity, needs, and desires.

4.4.2 Phase Two

At the end of the fourth week the first interim report was prepared and discussed by the design group. After feedback from the design group it was the consensus that the various task groups' efforts were not compatible. The Users Task Group decided it should not continue with its current objectives and approaches until further developments of the sources, the processing capabilities, and the dissemination channels were further defined. One reason for this decision was that the constraint of man-power, time, and money would not allow a statistical significant sample of the user community to be collected.

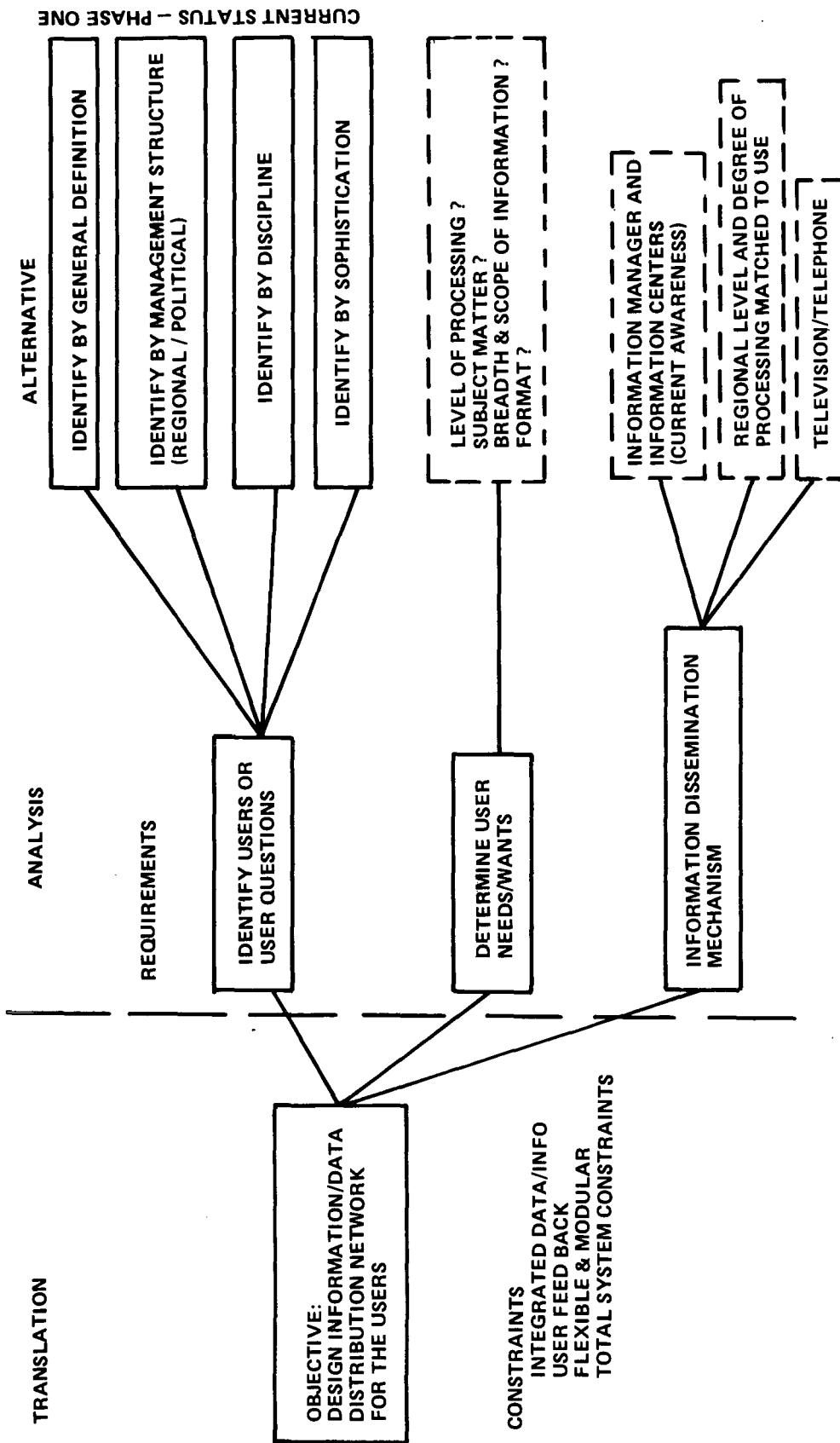


EXHIBIT 4-6: STATUS OF USER TASK FORCE AT THE END OF PHASE ONE

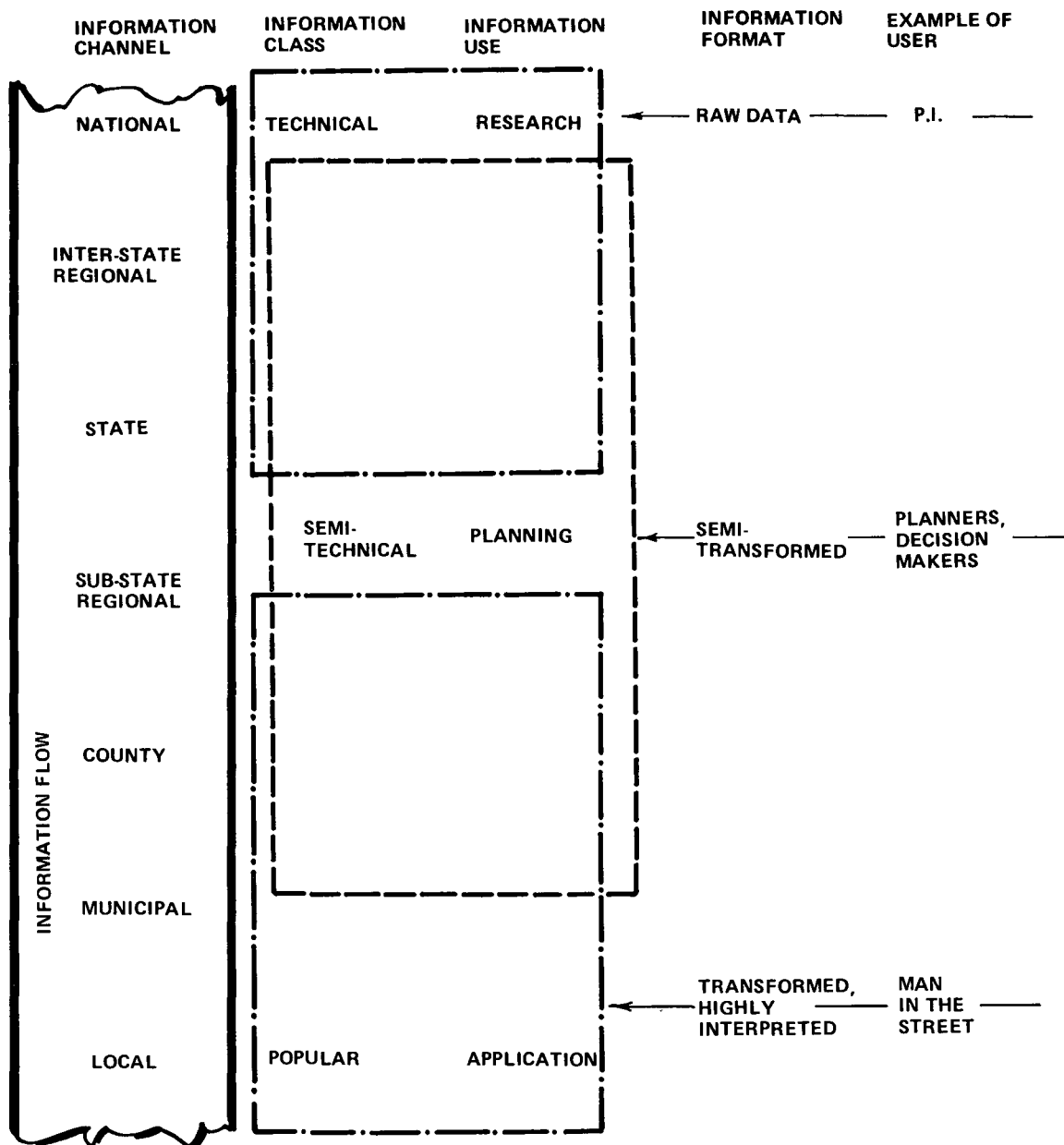


EXHIBIT 4-8: INFORMATION DISSEMINATION ARRAY

After this feedback the User Task Group restated its objective as:

to develop a conceptual design of the user services aspect for ERISTAR.

The requirements of this objective were:

- to develop a methodology for delineating user applications and requirements (time, format, content, media)
- to develop a methodology for creating an ERISTAR awareness in the user community
- to develop a methodology for training users of the ERISTAR
- to develop a methodology for creating a management structure for the user application function in the ERISTAR

These requirements and the approaches to accomplish the objective are illustrated in Exhibit 4-9 with further detailed analysis illustrated in Exhibits 4-10 through 4-12.

At this point the User Task Group had developed a large series of detail decision criteria charts. These charts attempted to specify the alternatives for defining the user services functions. The specific selection of alternatives were to be made by the project design group during the trade-off stage.

4.4.3 Phase Three

The second interim report was prepared and discussed. Out of this, three important conclusions were reached by the User Task Group:

1. The decision criteria charts which had been developed indicated important interfaces with Sources, Processing, and Management.
2. Essentially some gross trade-offs had occurred within task groups, and more detailed trade-offs among groups would follow.
3. The User Task Group should use the detailed charts of Phase Two to develop the concept of an ERISTAR Center as it related to the user services aspects.

Group discussion resulted in the conceptual elements of a typical ERISTAR Center. (Refer to Exhibit 6-4.) One of these elements is User Services, for which the functional aspects were developed. The result was the User Services Division discussed in section 4.2 and illustrated in 4.3.

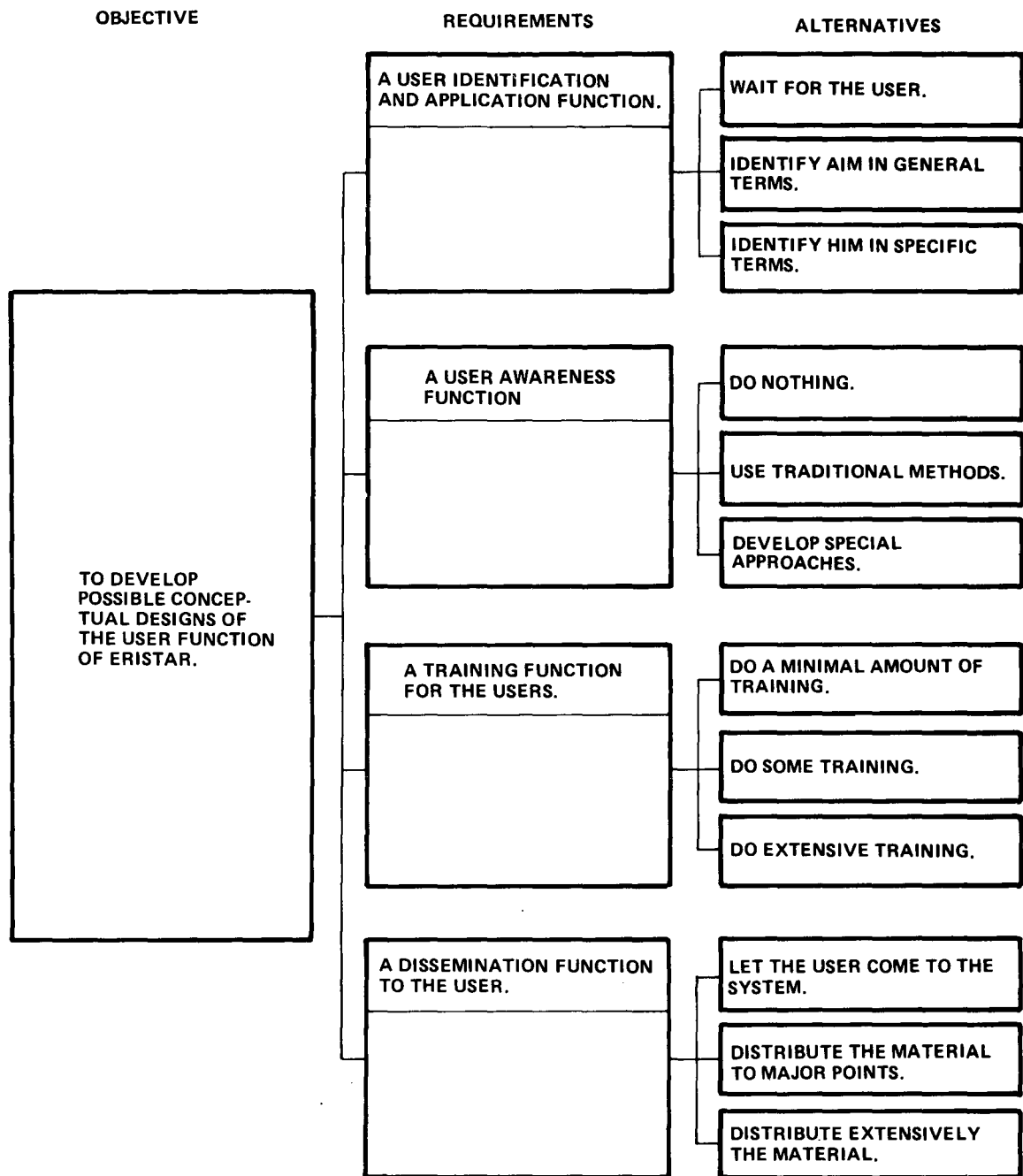


EXHIBIT 4-9: REVISED OBJECTIVE OF USER TASK GROUP - PHASE TWO

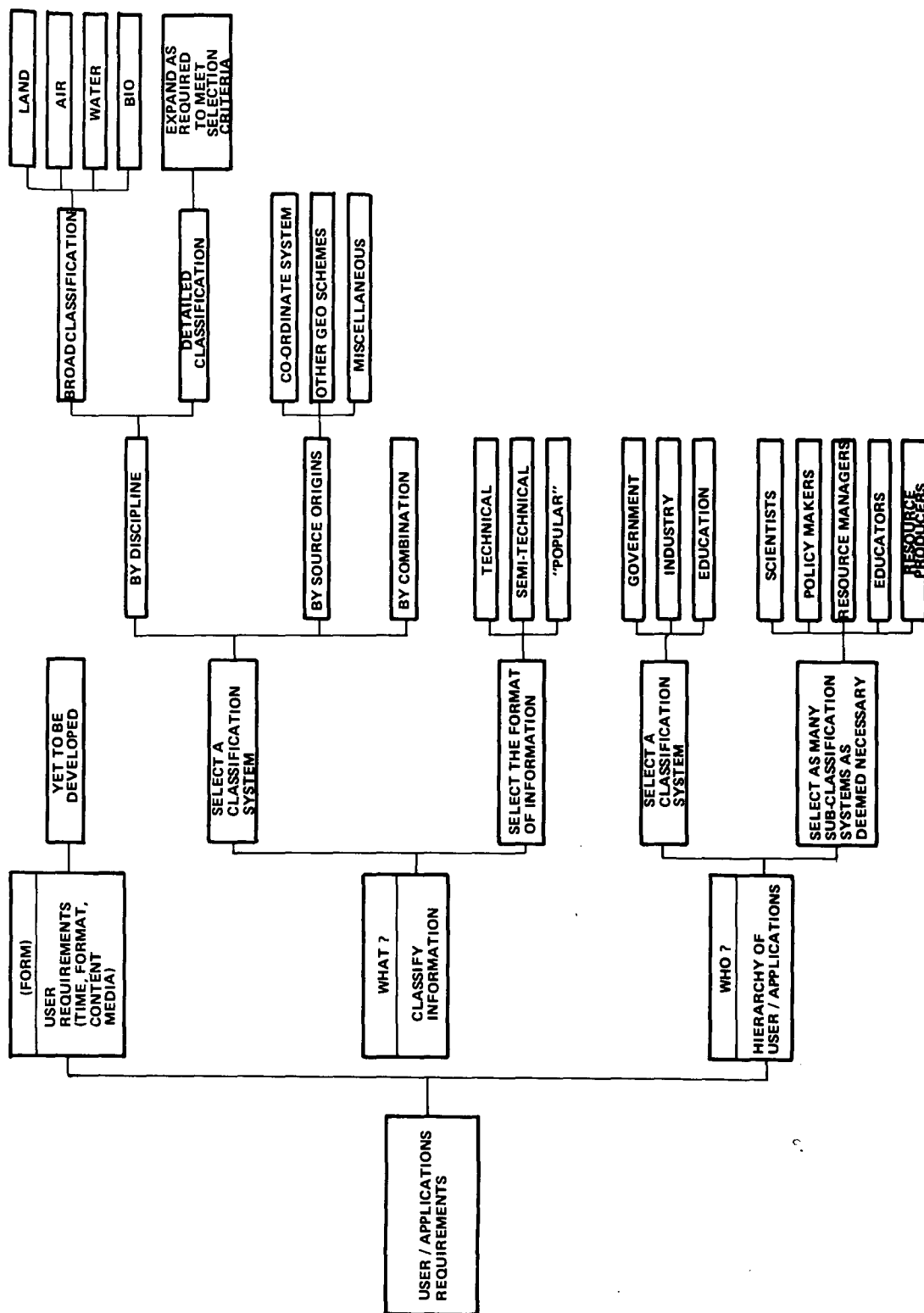


EXHIBIT 4-10: DECISION CRITERIA FOR DETERMINING USER / APPLICATION REQUIREMENTS

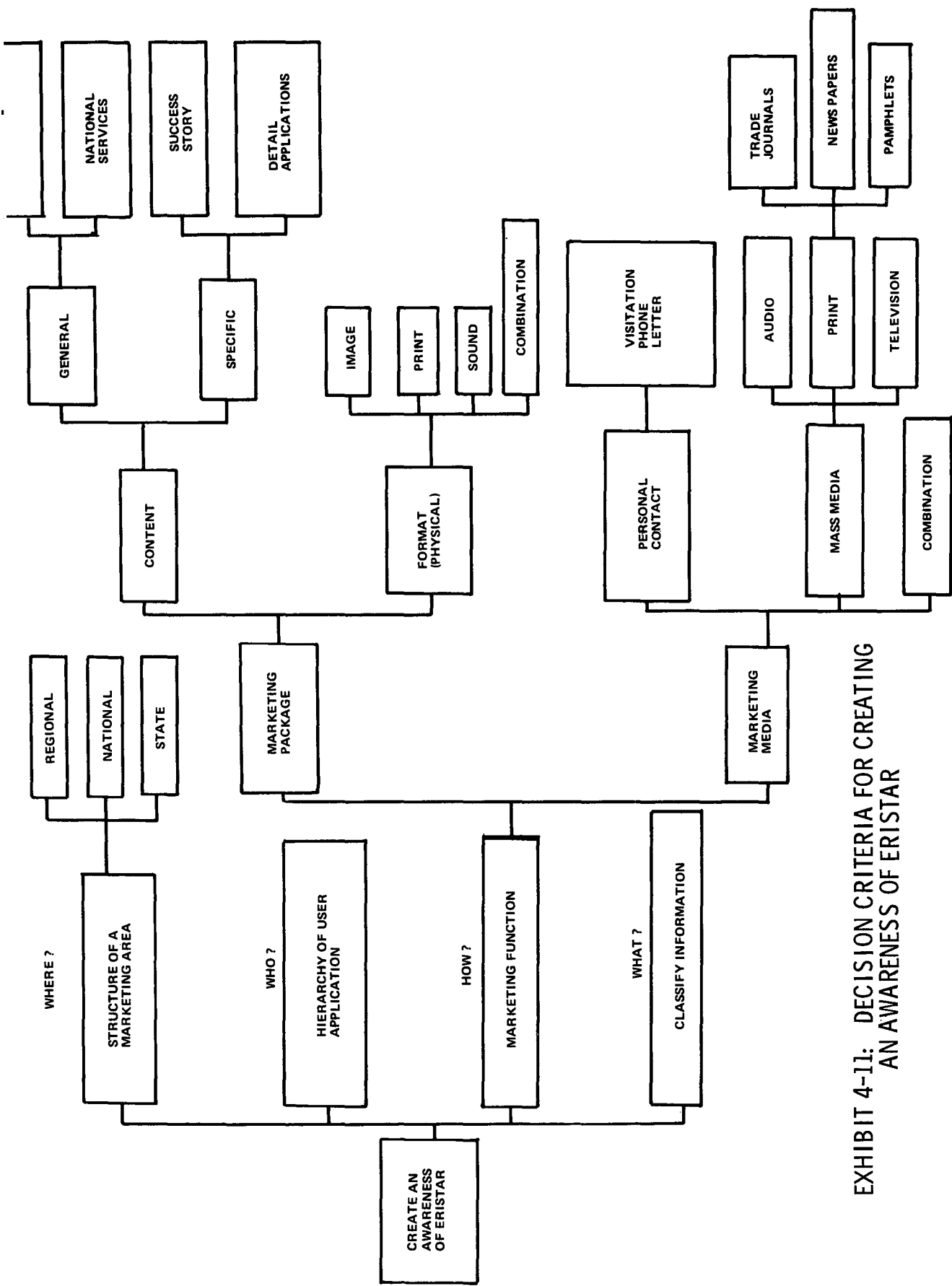


EXHIBIT 4-11: DECISION CRITERIA FOR CREATING AN AWARENESS OF ERISTAR

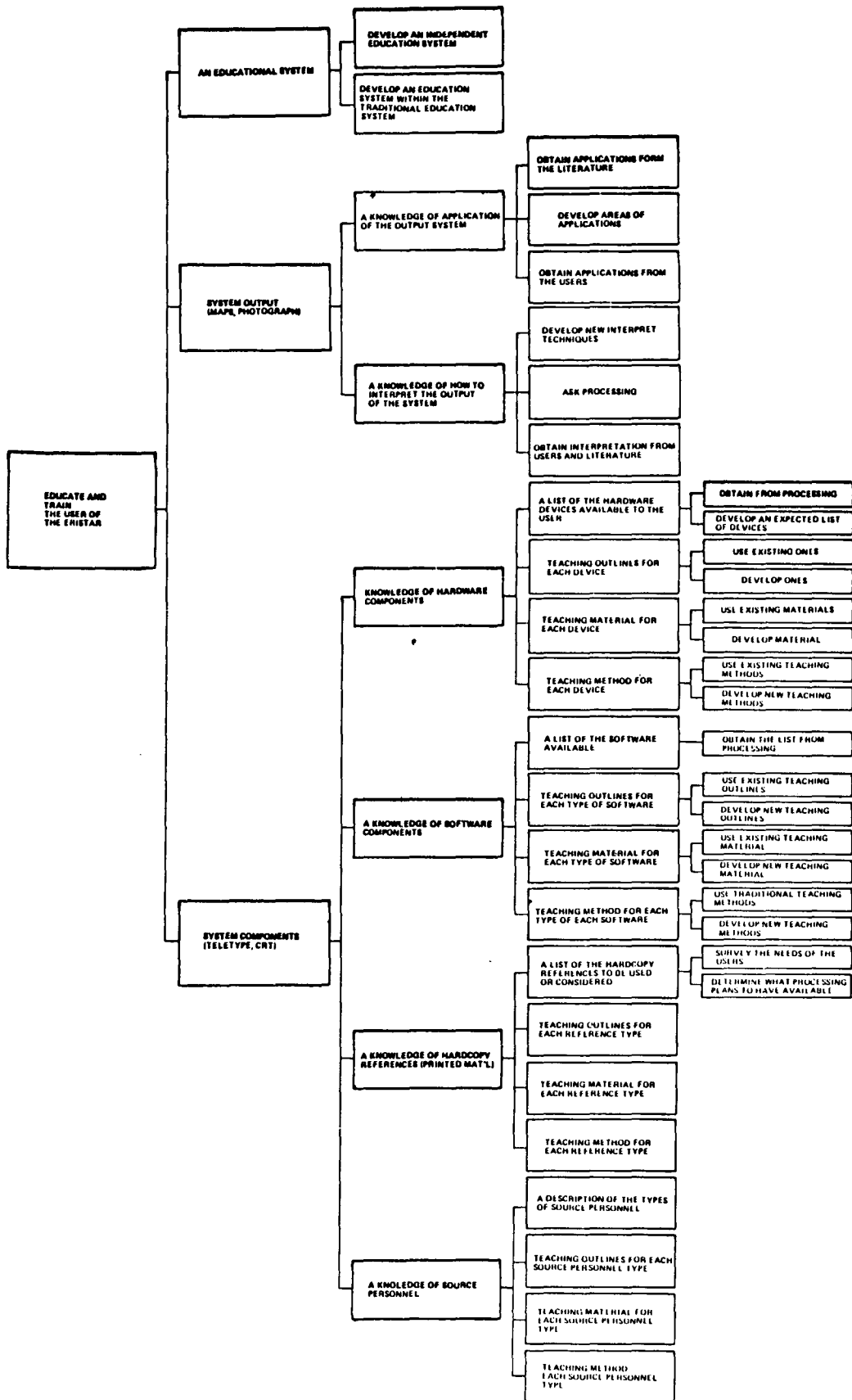


EXHIBIT 4-12: DECISION CRITERIA FOR EDUCATING AND TRAINING ERSTAR USERS.

4.5 SUMMARY

The prime objective of ERISTAR is to satisfy the needs of users of earth resources data. To accomplish this objective it is necessary that a dynamic User Services Division exist. This service must be the primary force in determining what type of data will be collected and how it will be presented to the user.

The basic foundations for the Users Services Division have been developed as specified in section 4.2. Future work should be devoted to the following:

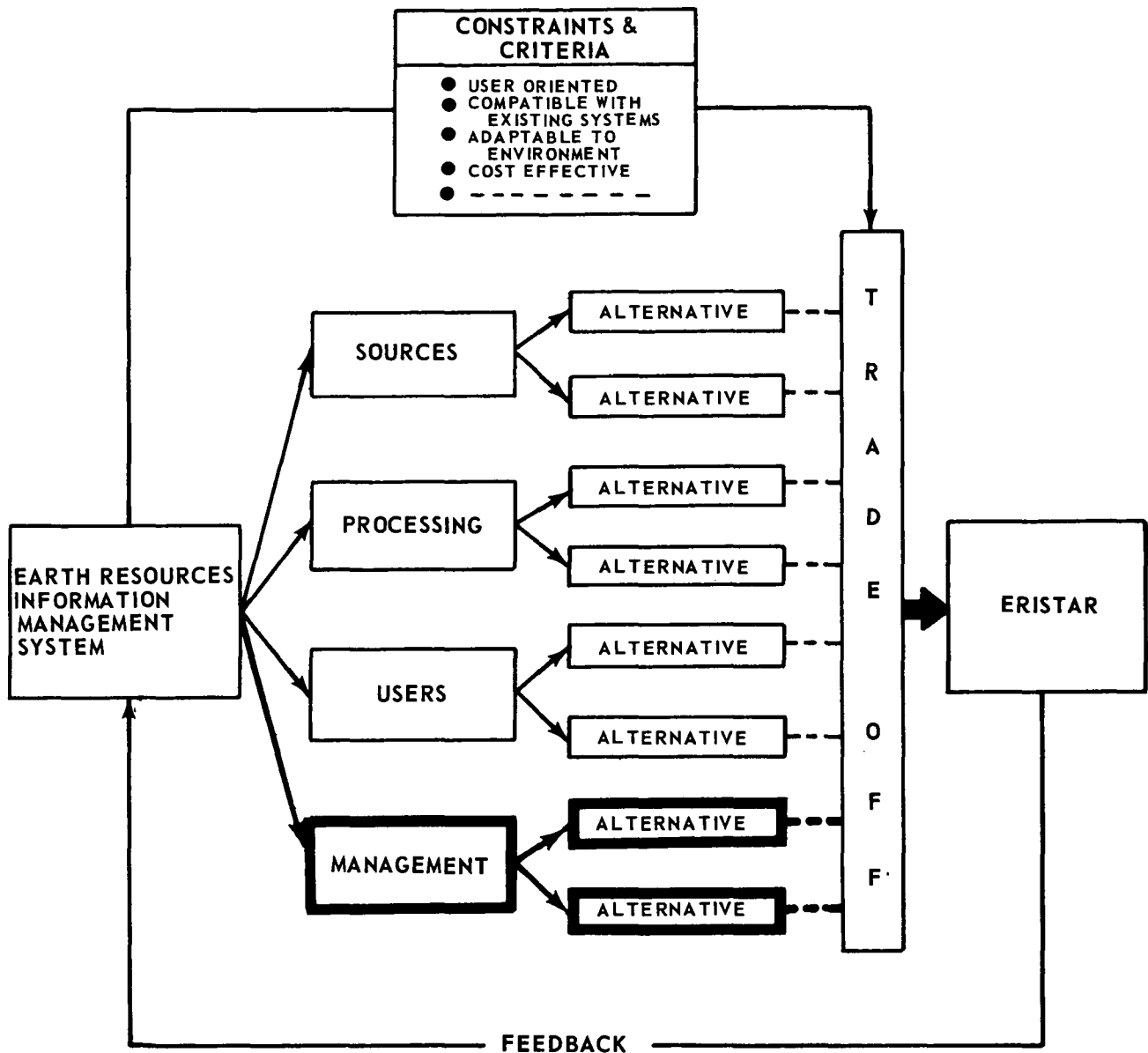
- ° co-ordinating these basic concepts with the other elements of ERISTAR
- ° developing in more detail, the specific services and level of services to be offered.
- ° specifying the initial level of Center Operations and a pattern for growth.

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5. MANAGEMENT



5.1 INTRODUCTION

"Managing is....the design or creation and maintenance of an internal environment in an enterprise where individuals, working together in groups, can perform efficiently and effectively toward the attainment of group goals." [1]

An enterprise which has as its goal the efficient and effective management of information must itself be efficiently and effectively managed. A discussion of the components of a management structure for information management systems [2] has been helpful in developing a conceptual design for the management of ERISTAR.

The first step toward the conceptual design of a management structure for ERISTAR is to establish and define its functions. The seven general functions of management of any organization are shown as "Requirements" in Exhibit 5-2 [3]. The seven functions may be subdivided into more specific functions, pertinent to ERISTAR, for which the management must develop policy:

- Initial Financing
- Organization
- Ultimate Authority
- Planning
- Research
- Public Relations
- Marketing
- Education
- Data Analysis and Processing
- Data and Information Maintenance
- Equipment Maintenance and Support Services
- Interfacing
- Sources
- Operational Financing
- Personnel
- Legal
- Priorities
- Security
- Monitor
- User Entry

The remainder of this chapter will be devoted to elaboration on the functions just listed and to the steps in selecting a structure to assure the efficient and effective management of these functions. The criteria used to evaluate candidate management structures are listed for convenience in Exhibit 5-5 and are discussed in detail in section 3.3 of this report.

Source, Processing and User considerations, discussed in detail in chapters 2, 3 and 4 can be managed best by means of a hierarchical network of information centers. The network defines the lines of authority

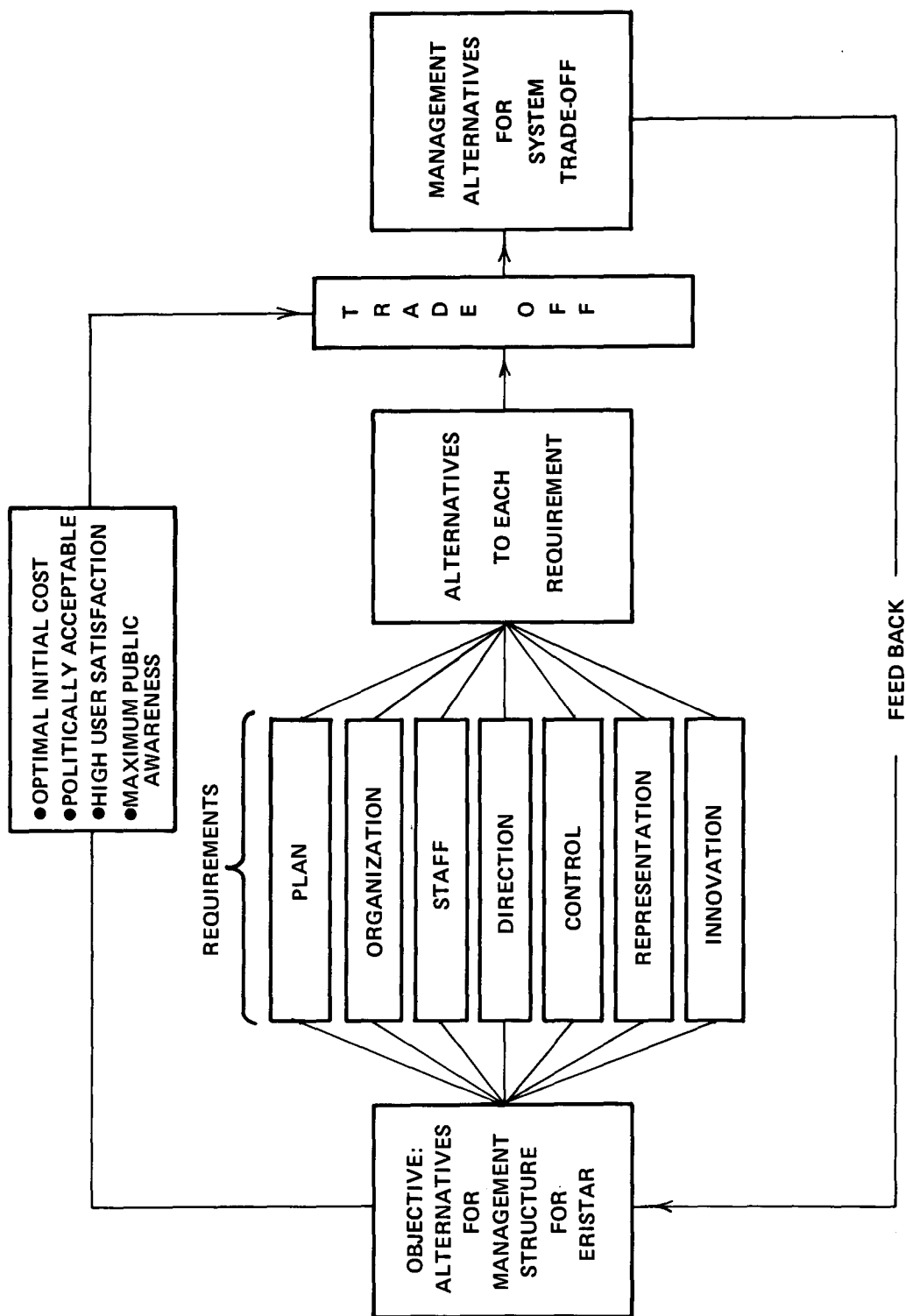


EXHIBIT 5-2: OBJECTIVE AND REQUIREMENTS FOR THE MANAGEMENT STRUCTURE OF ERISTAR

or control within ERISTAR. The centers are the working nodes of the network. Users will access the system through centers. Centers will be responsible for processing, analysis, storage, retrieval and all other activities necessary to give the best possible response to a user query. Management functions particular to the network are discussed in Section 5.2 while those functions particular to the centers are discussed in section 5.3.

5.2 ERISTAR NETWORK

The earth resources information management system may be considered as a network, that is, a number of centers in communication with each other. In addition, each center may be administered by the federal or state government, or by private means [4, 5, 6]. For purposes of illustration, consider the simple two-center network shown in Exhibit 5-3. The circle at the top of the drawing represents a center which is administered by the federal government. The triangle at the bottom represents a center which is administered by a state. The line broken by circles represents the fact that the federal center exerts complete control over the policies of the state center.

The selection of a network configuration for ERISTAR precluded the alternative of having a single national ERISTAR office which would be accessed by the user via phone, mail, etc. The design group made this choice after evaluating both alternatives in terms of the criteria shown in Exhibit 5-5. In particular, it was concluded that a network would

- (a) allow greater use of existing facilities,
- (b) be less susceptible to charter infringement,
- (c) provide reduced source and entry effort,
- (d) be more politically acceptable at the state level,
- (e) have the potential for greater adaptability.

There is an enormous number of possible network configurations for an ERISTAR system. In order to limit this number to a tractable size, the management task group concluded that centers would be arranged in a hierarchy of four levels; namely, national, regional, state, and sub-state levels. Some of these hierarchies were in turn eliminated since, for example, they included such politically infeasible alternatives as having many state centers control the policies of a single federal center. The resulting list of sixteen alternatives is displayed in Appendix D.

For reasons of manageability and, in particular, the notion of "span of control", those alternatives which did not display regional centers were excluded. Further, it was the consensus of the design group that centers administered by the private sector be dropped from consideration. This reasoning reduced the number of alternatives to two; namely, one alternative in which all centers were federally administered (see Appendix D-1), and the joint federal-state network structure

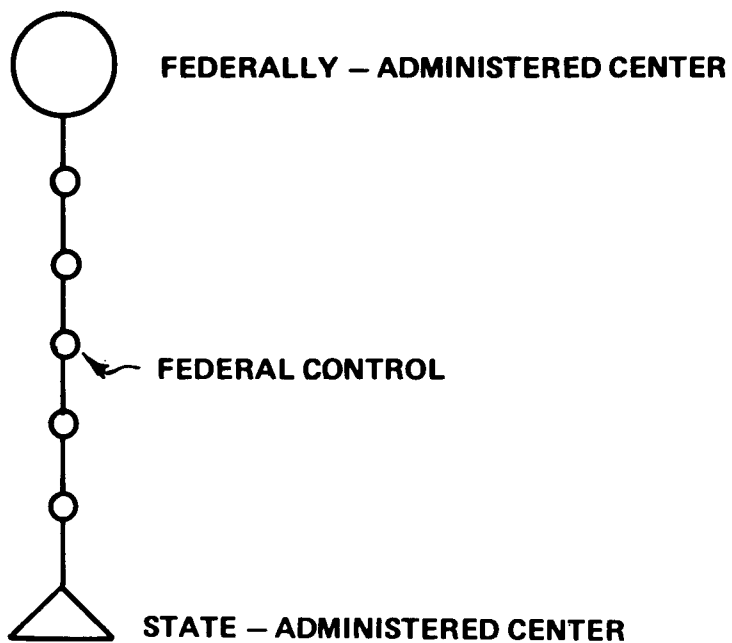


EXHIBIT 5-3: TWO-CENTER NETWORK

displayed in Exhibit 5-4. In terms of the criteria and constraints shown in Exhibit 5-5, the joint federal-state network was selected because it appears to be more politically acceptable while at the same time providing increased adaptability. That is, the joint federal-state structure is more likely to gain acceptance since some of the controls are "closer to home". In addition, responses to a changing environment at the state or sub-state level would be less inhibited by a diminished bureaucracy.

If federal financial assistance is necessary, it should be provided on a matched-funding basis. This should assure that the states maintain a responsible attitude toward their center. An example is the funding arrangement available from the Environmental Protection Agency for the establishment of state environmental study centers.

5.3 ERISTAR INFORMATION CENTER

With the exception of Organization and Initial Financing, all functions listed in Section 5.1 (for which management policy must be established) pertain to ERISTAR information centers. These functions will now be elaborated on with alternative approaches to functions shown where pertinent. When alternative approaches are not specified, it is implied that the management alternatives are:

1. Centralized management
 - a. Staff
 - b. Line
2. Decentralized management

Establishment and definition of functions is an appropriate first step in development of a management structure (i.e., organizational chart) for an ERISTAR information center.

5.3.1 Information Center Functions

The eighteen functions for the ERISTAR management are listed and defined in the following sections.

5.3.1.1 Ultimate Authority

An information center like any other human organization, must include a means to establish decision making authority, and hence must have a component which has ultimate responsibility and authority for the operation of the center. Approaches to this authority component are:

1. A single person (director, manager, president, etc.)
2. A board of directors
3. A management committee

The same component may have ultimate responsibility and authority for center policy or it may be subject to policy dictated by centers which are administratively superior to it. In all cases, each center's role in the authority network is negotiated with or administered by the authority component of the center.

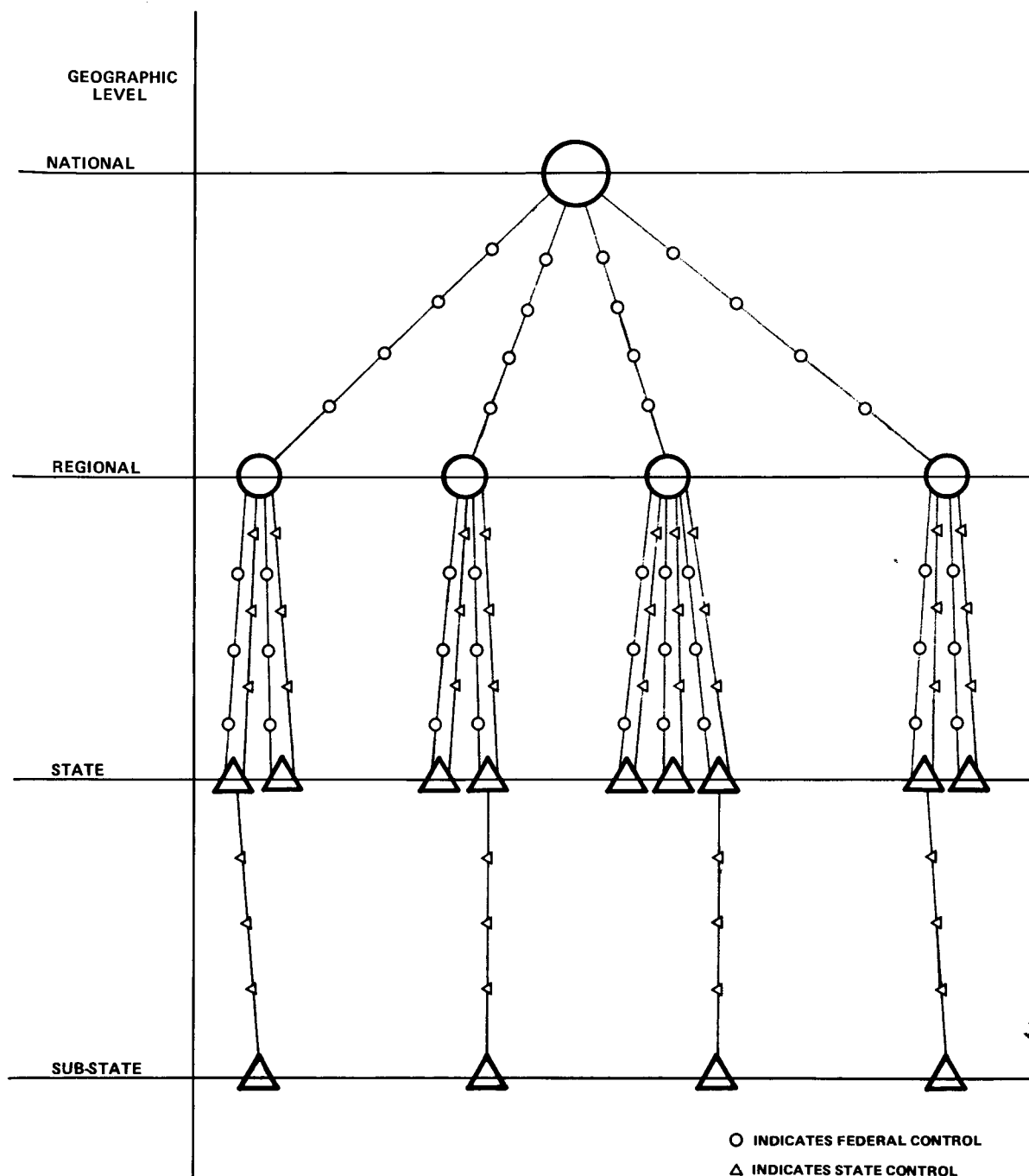


EXHIBIT 5-4: ERISTAR NETWORK

CONSTRAINTS

- Financial
- Timing
- Consistency with Existing Agencies
- Technology

NOTE: These criteria and constraints are defined in Section 3.3.

CRITERIA

System Operation and Administration

- Cost
- Reliability
- Duplication
- Adaptability
- Manageability
- Monitoring Capability
- Transferability
- Compatibility

System Effectiveness

- Political Acceptability
- Interaction
- User Effort
- Response Time
- Capability
- Entry Effort
- User Satisfaction (Availability, Accessibility, Recall, Precision, Coverage)

EXHIBIT 5-5: CONSTRAINTS AND CRITERIA FOR SELECTION OF MANAGEMENT STRUCTURE

5.3.1.2 Planning

Toffler [7] states that there is a "...call for permanent revolution in organizational life, and more and more sophisticated managers are recognizing that in a world of accelerating change reorganization is, and must be, an ongoing process, rather than a traumatic once-in-a-lifetime affair". As a new "industry" dealing with a rapidly changing product and serving hazily defined, constantly changing markets, the information industry must pay careful heed to Toffler's words. An important function of ERISTAR is thus to examine changes, internal and external to the system and make plans to allow orderly modifications in the administration to meet real and anticipated developments in technology and changes in the market.

5.3.1.3 Research

Before administrators can administer wisely and planners can plan intelligently, information must be accumulated and reviewed. One information input to administration and planning comes from technological research. It is here that innovative solutions to new problems hopefully will arise. New hardware and software components may be developed. New analytical techniques may be perfected. The research function of ERISTAR includes both active design of new systems and literature searches to stay current with the products of research by others. This does not imply that ERISTAR should have an earth resources data taking (measurement) function. It does mean that ERISTAR can assist users in the development of specialized data taking devices/techniques either in house or by the services of a consultant such as NASA. It also means that ERISTAR must have the capability to research its market.

5.3.1.4 Public Relations

Marketing, administration, education, and other functions of an organization are facilitated if the organization can develop and maintain a good public image. Public relations research and publications are extensive [8, 9]. Reference to those publications may be made to further define a public relations function in ERISTAR.

5.3.1.5 Marketing

Policies concerning such things as fees, advertising, distribution, etc. are no less important when the product is information as they are when the product is a piece of equipment. It is management's responsibility to make provision for surveying the existing market and studying potential changes in the market. The customer (user) must be studied in the greatest possible detail so that ERISTAR can demonstrate how its service will be beneficial to the customer (user). ERISTAR must sell its product both to those who initiate contact with the information system and to those who are unaware of potential benefits.

5.3.1.6 Education

Education must be subdivided into two subfunctions: (1) education of center personnel and (2) education of the public. The first subfunction may be satisfied by short courses, seminars, etc. It is management's responsibility to determine when employee or staff education is necessary or advisable and it is management's further responsibility to have appropriate educational efforts implemented. The second subfunction must be managed so that the general public is first educated about ERISTAR and then educated in the techniques of use of ERISTAR.

5.3.1.7 Data Analysis and Processing

Management must insure the availability of data analysis and processing capabilities commensurate with user requests. This pertains to computer techniques as well as the more classical, precomputer methods.

5.3.1.8 Data and Information Maintenance

Central to the useful operation of an information center is the maintenance of current data base. It is a management duty to establish policy for the following:

1. deletion of obsolete information
2. transfer between active and inactive storage
3. introduction of new information
4. authority for making changes in the data base

In meeting this responsibility, the management must take into consideration the fact that the data may take many diverse forms (specimens, books, periodicals, microfiche, maps, charts, computer forms, etc.).

5.3.1.9 Equipment Maintenance and Support Services

Management must see that the practical and vital support activities of ERISTAR function efficiently and facilitate the operation of the information center as a whole. Some typical activities are:

1. custodial services
2. secretarial pool
3. mail room
4. graphics (cartography, drafting, photography)
5. duplicating and printing

Equipment maintenance is set aside from the other support services because it is anticipated that many information centers will include computer capabilities.

5.3.1.10 Interfacing

Management must be concerned about the technological and political problems attendant to interfaces (1) between centers and facilities within

ERISTAR and (2) between ERISTAR and other information systems (both foreign and domestic). The technological problems (hard/software) related to interfacing are the easiest to manage and should be dealt with by the Center and Network Operations division of ERISTAR. By far the more difficult and important aspect of interfacing is the negotiating necessary to create an interface. Interfacing with other information systems, foreign and domestic, will raise significant challenges to the diplomatic abilities of the management.

5.3.1.11 Sources

Responsibility must be assigned for specification of data and information necessary for the operation of ERISTAR. Once the specified source materials have arrived at the center, management will provide means for their incorporation in the data base.

5.3.1.12 Operational Financing

The operational financing function of ERISTAR management is not different from other organizations. Attention must be paid to:

1. payrolls and other disbursements
2. billing and collecting
3. operating budget

5.3.1.13 Personnel

This is a standard function of the management of any organization. Job descriptions must be written, prospective employees interviewed, screened and hired. Employee resignation, termination and retirement procedures must be established. The importance of this function cannot be overstressed because it bears the responsibility for acquiring and keeping a qualified and satisfied staff of employees.

5.3.1.14 Legal

Nearly all the other functions of management rely on legal counsel for efficient performance. A few areas to which the legal function applies are:

1. copyright
2. intrastate and interstate regulations
3. international regulations
4. communications
5. employee relations

5.3.1.15 Priorities

Although it may be the goal of the information system to do everything for everyone, management must be sure that trivial problems do not unduly interface with more important information activities of the system. The

management must establish policy for apportioning center time and effort according to the importance of the problem.

5.3.1.16 Security

It is a function of management responsibility to establish policy with regard to system data security. Management has several options to choose from, among which are:

1. no security--all data and information is in the public domain,
2. management determines what data security measures will be taken on what data,
3. information sources and users of ERISTAR specify the security of their data.

5.3.1.17 Monitor

System administration falters without accurate, detailed information about what is happening in the system. Plans for system changes may be inappropriate if the planner does not know what needs changing. System monitoring in this sense must therefore include MIS (Management Information System) capabilities.

5.3.1.18 User Entry

Perhaps the most important responsibility of management is to establish the means by which a user will gain access to ERISTAR. A high quality product will go to waste unless the user (customer) has a simple and appropriate access to it.

5.3.2 INFORMATION CENTER MANAGEMENT STRUCTURE

The next step in the development of a conceptual design of a management structure for ERISTAR is to trade off the alternative ways of performing these functions (discussed in section 5.3.1) under the constraints and criteria shown in Exhibit 5-5. The most important controls on the design of the management structure of an information center are the following:

- Duplication of activities within the center
- Manageability
- Transferability of the management structure to centers of different size and degree of sophistication.

The other constraints and criteria in Exhibit 5-5 are important to the conceptual design of the total system and management must guarantee that all these controls are adhered to in day-to-day operations. However, only Duplication of activities, Manageability and Transferability play a major role in determining the management structure through which the other constraints and criteria will be met as the information center performs its functions.

It should be evident that a well managed information center will show a minimum of duplication of activities (i.e., only one subdivision of the center will perform analyses of the user market and the results of the efforts of workers in that subdivision will be made available to the entire center). It should also be evident that the more manageable the center, the closer will its functions be performed to the optimal trade-off level.

The importance of transferability is not self-evident. It is this criterion which dictates that the management structure must work well for centers showing wide variability in physical size, volume of user queries and breadth of disciplines of information which can be dispensed. For example, the management structure should be set up so that several functions can be performed by one person in a small center or one function can be performed by several persons in a large, high volume center, without a fundamental change in the structure. The structure should also be modular to the extent that a given center can elect to drop a maximum number of functions with a concomitant minimum reduction in service to the user. For example, a small, state level center may find that it does not have a sufficiently high volume of user queries to warrant financial support for legal services or research facilities. It may be small enough that the center manager does not need special monitoring, security or processing capabilities. Yet it must still be able to dispense the highest quality information possible in a form which is of greatest possible use to the user.

The center management structure which best meets all criteria and constraints is shown in the form of an organizational chart in Exhibit 5-6. The boxes are divided to show both the function and the title of a person to perform that function. The titles chosen to fill the various boxes are typical of titles used in business. Whoever assumes control of a center can change the titles without affecting the function. A list of management responsibilities of an ERISTAR center staff is shown in Appendix D.

The upper parts of the organizational chart, Exhibit 5-6, are standard for the management of any business or agency. The unique portions of the management structure are shown in the bottom most three boxes, e.g., Information Analysis & Processing, Center and Network Operations and User Services. The details of management structure of these three boxes are shown in Exhibits 5-7 through 5-9. Exhibit 5-10 shows how these functions are related to the general flow of information through an ERISTAR Center.

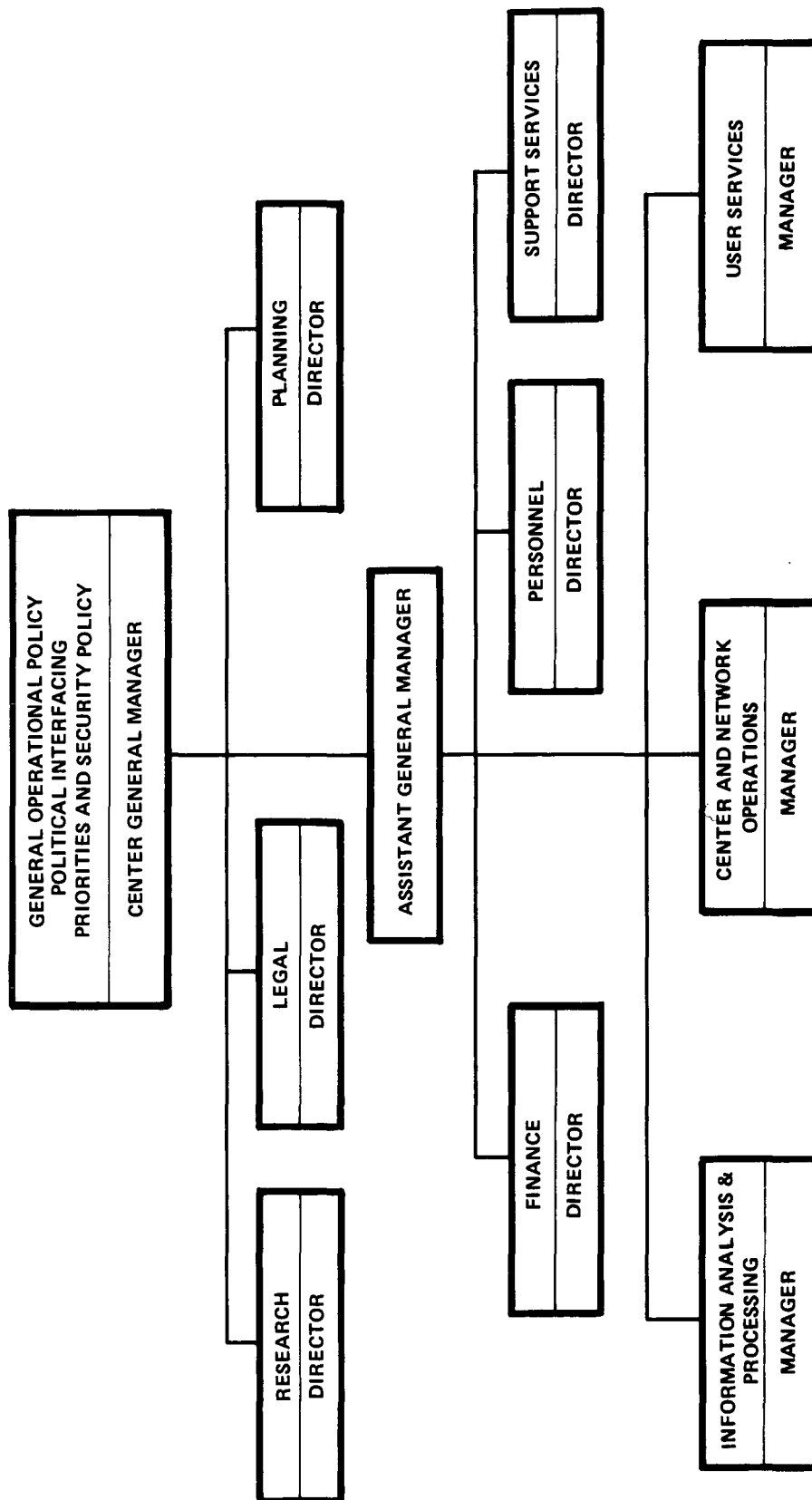


EXHIBIT 5-6: EXAMPLE ORGANIZATIONAL CHART FOR AN ERISTAR CENTER

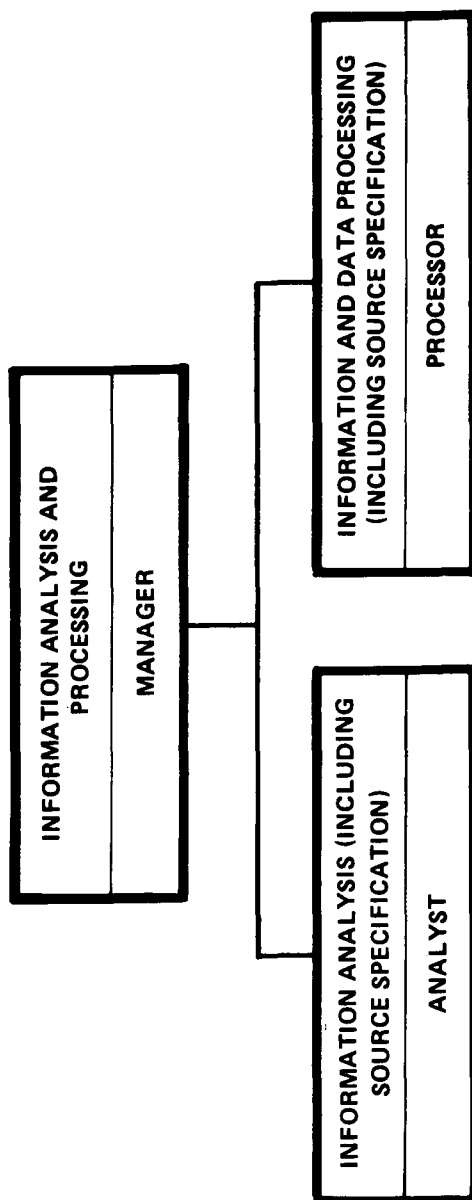


EXHIBIT 5-7: DETAILED ORGANIZATIONAL CHART FOR INFORMATION ANALYSIS AND PROCESSING

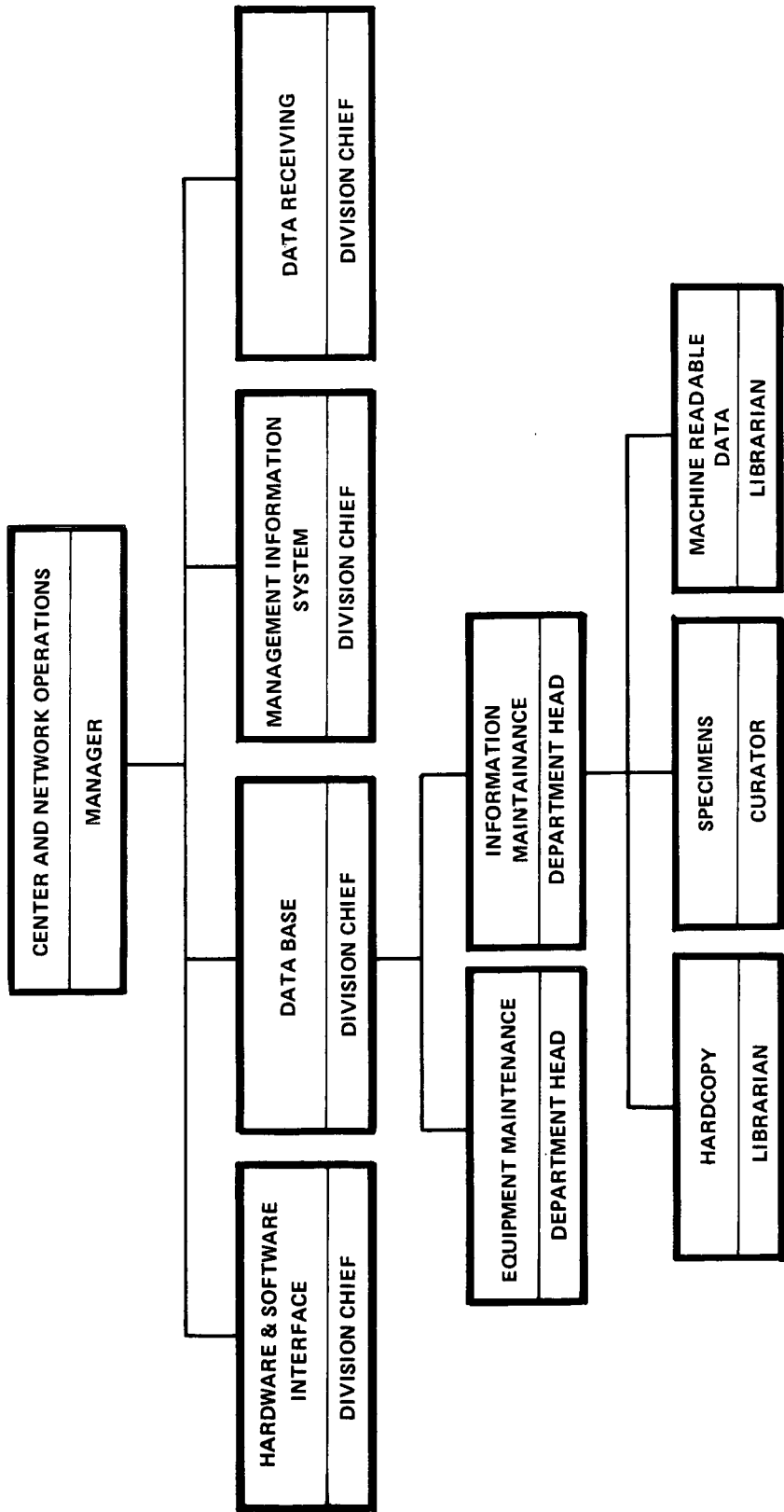


EXHIBIT 5-8: DETAILED ORGANIZATIONAL CHART FOR CENTER AND NETWORK OPERATIONS

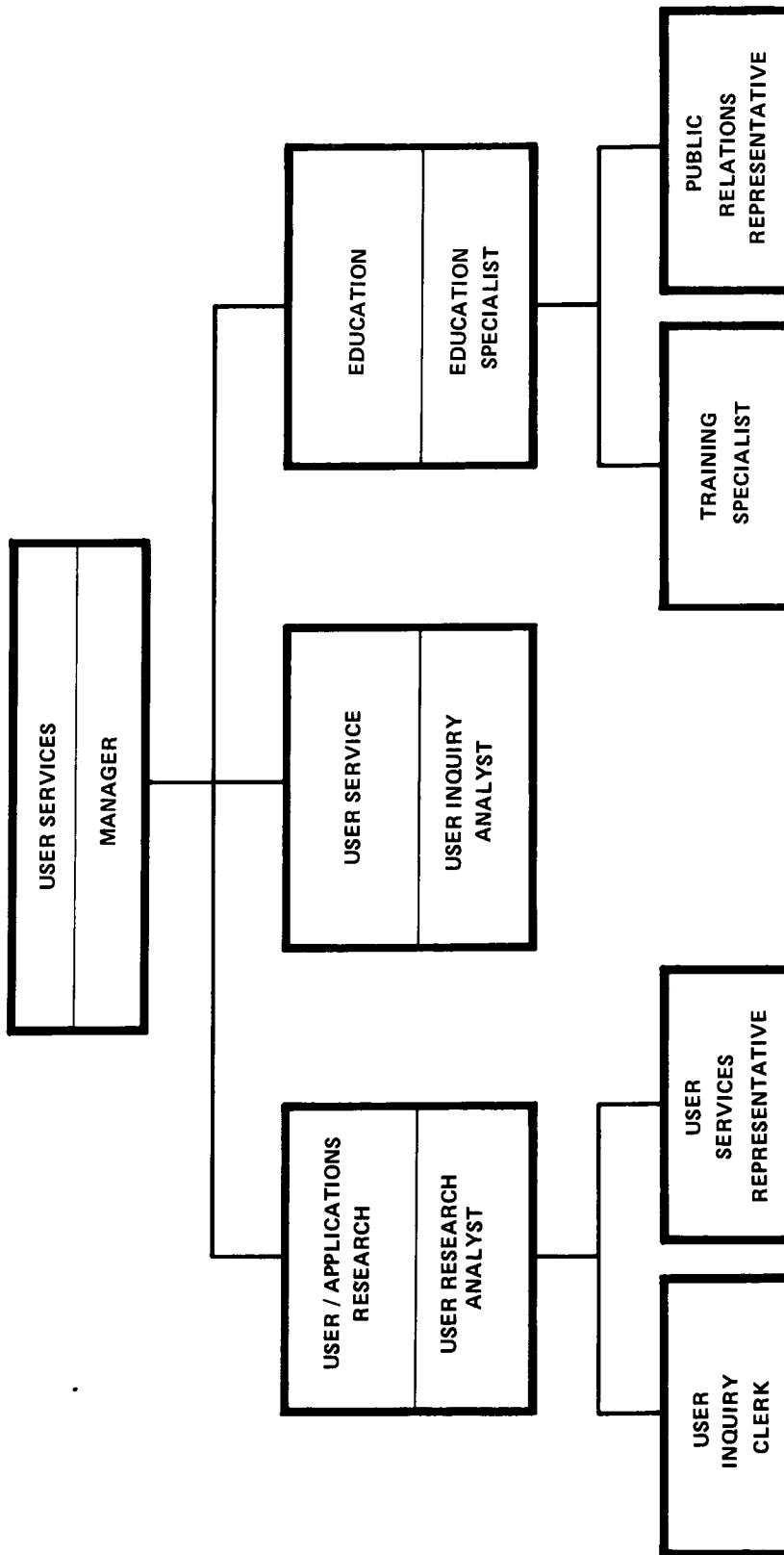


EXHIBIT 5-9: DETAILED ORGANIZATIONAL CHART FOR USER SERVICES

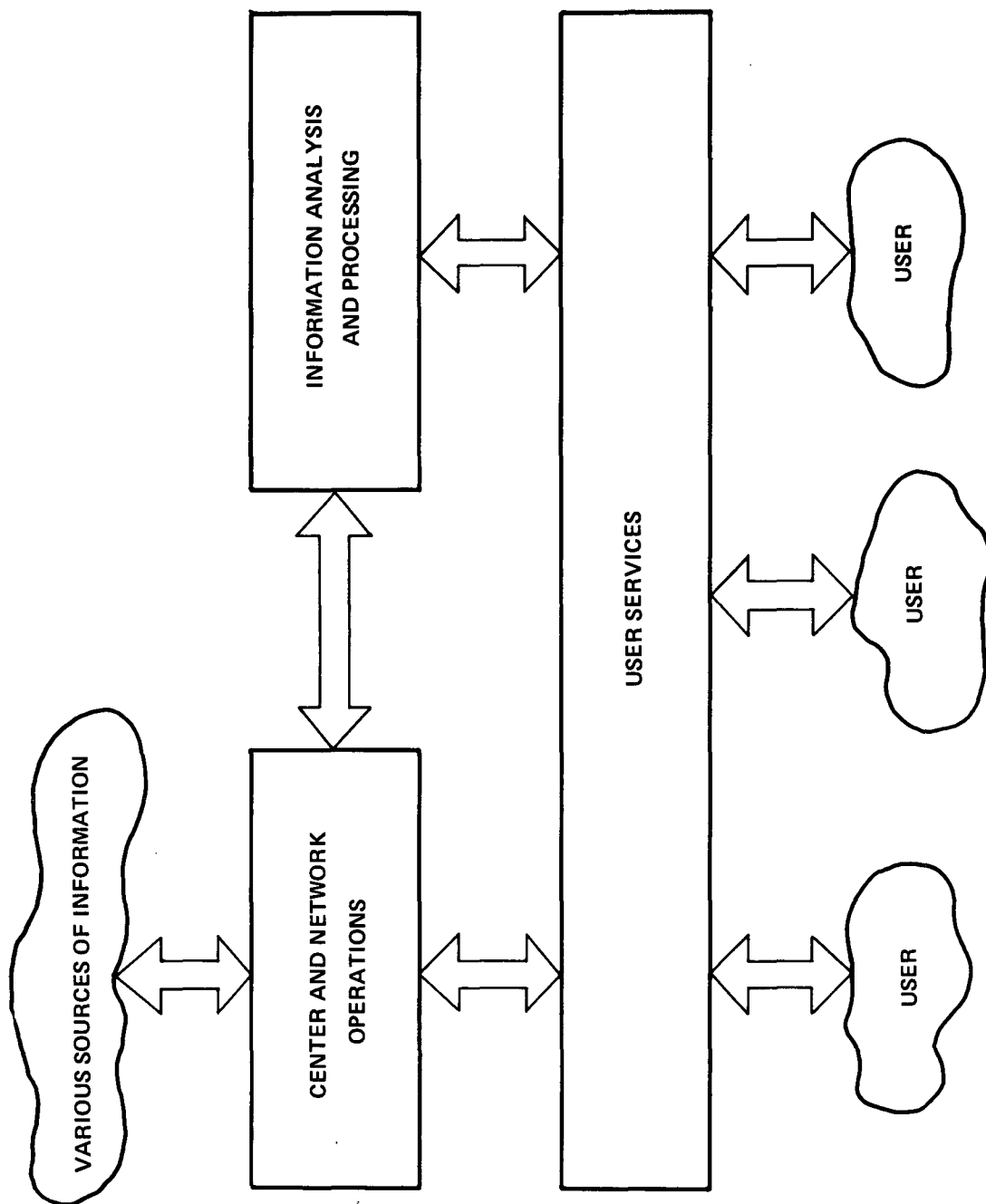


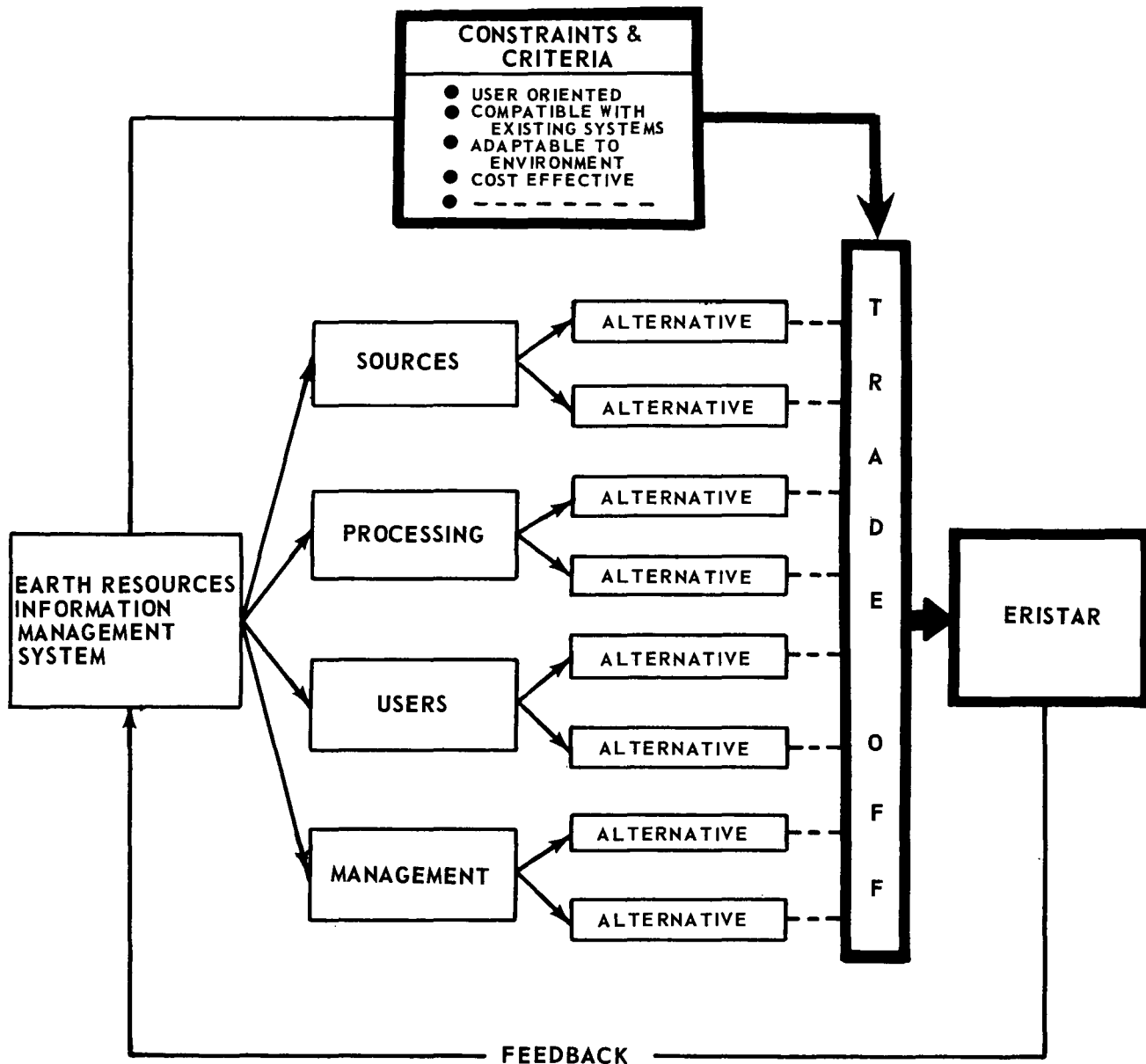
EXHIBIT 5-10: INFORMATION FLOW THROUGH AN ERISTAR CENTER

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6. ERISTAR



6.1 INTRODUCTION

The final product of the design effort is the ERISTAR system plan, which results from trade-off analyses of the alternative approaches. Only the higher level trade-offs have been made and, where appropriate, the rejected alternatives are discussed along with the reasons for their elimination.

The plan formulated here represents a coordinated approach to the management of all types of earth resources information which not only can result in the more effective use of the information at all levels, but also can yield significant savings through the elimination of redundant and unnecessary data collection programs.

6.1.1 Constraints and Design Philosophy

In the world of information systems the terms "user-oriented" and "cost-effective" hold the same unquestioned positions as "God, country, motherhood" in a fourth of July political rally. The trick, of course, is to determine exactly what "user-oriented" means, and to design a system that is truly "cost-effective". Nevertheless, the guiding principles used in the ERISTAR design were that the system be user-oriented, cost-effective, and integrable with existing systems. The following constraints were imposed upon the system design by the design group.

- ° Scope - the system must include earth resources information pertaining to the United States and serve users throughout the United States, i.e., the system is a national one related to earth resources.
- ° Financial - the annual operational cost, including the amortization of the initial cost to design and implement the system, must cost no more than \$560 million. This figure is based on a projected level of annual dollar benefits that can be achieved from the system. (See Appendix B-8).
- ° Timing - the initial system must be operational within a year, and the final design must be in operation within a decade.
- ° User Education - the system must provide appropriate, communicative education for the user in the technology of earth resources and in the use of the earth resources information system that is commensurate with his needs.
- ° Sources - data acquisition must be an efficient process to facilitate the collecting of relevant data, with the selection decision process linked to user requirements.

- Legal - the system must conform to current legal practices, including considerations of statutory law and individual rights.
- Cooperation/Integration with Existing Agencies - the system cannot infringe on existing agency charters or responsibilities.
- Research and Planning - the system must include research and planning functions.
- Security - the system must provide adequate security to protect the data files from both improper or erroneous erasure or modification (data base integrity) and from usage by unauthorized personnel, as well as protect the privacy of both source and user.
- Technology - the system must reflect the state of the art in the relevant technologies and keep pace with new developments.

6.1.2 System Requirements and Selection Criteria

In order for an earth resources information system to operate effectively, the following requirements must be met:

- Serve the user with the information he needs and wants
- Acquire data and information from appropriate sources
- Process the source information to arrive at the output desired by the user.
- Have a management structure which provides for efficient and effective operation.

These requirements have been analyzed in detail in Chapters 2 through 5.

It is clear that the driving force in the system design should be the information needs of the users. Data should not be acquired simply "because it is there." Nor should processing be performed only because the capability exists. Yet no analysis of the users' needs today can be of significant value ten years from now. The membership of the user community will certainly change over a period of time, and the needs of a given user will also be modified. The system itself must be able to identify the needs of its current and potential users, and to adapt its structure and operation as conditions change.

But even if the operating environment were to remain unchanged, if the users and their needs were constant, the system should have the ability to evolve and develop over a period of time so that it can more effectively perform its functions. Thus adaptability and evolutionary potential are two of the major selection criteria.

The complete list of selection criteria falls into two categories:

- system effectiveness - those measures for which a maximum value is preferred
- system cost - those measures for which a minimum value is preferred.

6.1.2.1 System Effectiveness

- Adaptability - The extent to which the system can easily respond to changes in the environment.
- Evolutionary potential - The ability of the system to evolve in scope, capability and structure over time from the initial implementation of the first design phase to the final design form.
- Political acceptability - The extent to which the system is worthy of receiving and capable of finding political support from the general public and from the established institutions of society.
- Public awareness - The extent to which the system can make itself known to the general public and to the established institutions of society.
- Interactive capability - The extent to which the system allows the user to enter his initial request and then alter it in midstream to get a better response, as well as helping him to interpret his needs and the system's response to those needs.
- User satisfaction - The extent to which the system can provide the greatest amount of satisfaction, in terms of information needs, to the greatest number of people.
- Transferability and compatability - The extent to which the system can transfer capability from one segment to another as necessary, and the extent to which the various components or modules of the system can work together harmoniously toward achieving system requirements.
- Monitoring capability - The extent to which the system can record or monitor its own activities, its environment, and the uses which are made of the system, so that the managers of the system can have the proper information and means by which to control and improve its operation.

- Manageability - The extent to which the system can easily and effectively be controlled, improved, and administered.
- Consistency - The extent to which the system fits in with existing agencies and their future plans.
- Cost-effectiveness - The extent to which the system provides an optimal and suitable return of benefits to society for the investment made in the system.

6.1.2.2 System Cost

- Initial cost - The capital expenditure required to implement and set up the initial system.
- Operating cost - The net annual expenditure required to keep the system in operation.
- Development time - The amount of time needed to implement and set up the initial system design into an operational system.
- Risk - The potential likelihood of the system to fail to meet its design specifications and performance requirements.
- Response time - The time lag between the entrance into the system of a user with a need for information and the delivery of the response of the system to that need.
- Duplication - The degree to which the efforts and facilities of effective existing information systems are duplicated by the system design.
- User effort - The exertion, physical and mental, required of the user in order to operate and negotiate the system. User effort is measured in terms of cost and inconvenience.

A summary of all the constraints and criteria is given in Exhibit 6-2.

6.1.3 Time-Phased Design Concept

The dimension of time is an important aspect of the system design. One might specify the structure of the system at a single point in time, but a more attractive approach is to present both a recommended design and an orderly plan for development. The ERISTAR design has been developed in three phases:

- initial - referral service
- intermediate - network of existing systems
- advanced - complete earth resources information network.

CONSTRAINTS

- Financial
- Timing
- User Education
- Sources
- Legal
- Cooperation/Integration
- Research and Planning
- Security
- Technology

Selection Criteria

System Cost

- Initial Cost
- Operating Cost
- Development Time
- Risk
- Response Time
- Duplication
- User Effort

System Effectiveness

- Political Acceptability
- Public Awareness
- Interactive Capability
- User Satisfaction
- Evolutionary Potential
- Adaptability
- Transferability and Compatibility
- Monitoring Capability
- Manageability
- Consistency
- Cost-Effectiveness

EXHIBIT 6-2: SUMMARY LIST OF CONSTRAINTS AND CRITERIA

Exhibit 6-3 shows the approximate dates by which the different phases might become operational.

This approach to the system design minimizes initial investment, provides an immediate operational capability, and allows for evaluation and decision at a number of points in time.

The structure and operation of the advanced ERISTAR system are discussed in section 6.2 together with some alternatives to be considered in refining the design. In section 6.3 is presented the plan for proceeding to the advanced phase via the initial and intermediate phases. In addition, section 6.3 recommends the implementation of a limited portion of the initial phase as a prototype or model to demonstrate the feasibility and effectiveness of the concept.

6.2 STRUCTURE AND OPERATION OF ERISTAR

The proposed ERISTAR system in its full form is a nationwide network of functionally similar information centers interconnected by a comprehensive communications system. The centers in the network are oriented toward detecting and fulfilling the earth resources information needs of a broad user community. The communications network extends to a complex of subject-oriented information analysis centers, numerical data centers, and to other external data and information acquisition and management systems. The network also includes a set of communications and information technology support facilities. These aid the main ERISTAR Centers in keeping abreast of new technological developments in data acquisition techniques and methods for storage, transformation, analysis and retrieval. The support facilities conduct basic and applied research and development in both hardware and software.

ERISTAR is designed to take full advantage of existing and forthcoming earth resources information programs and yet provide a coordinated, cost-effective approach to the acquisition, processing, and dissemination of that most vital ingredient in resource management--information.

6.2.1 The Network Approach

The alternative designs for a national earth resources information management system may be generally categorized as centralized or decentralized. A centralized approach based upon the TRIAD report [1] was discussed in section 3.5.5. However, an examination of the selection criteria in section 6.1.2 leads quickly to a decision in favor of a decentralized but interconnected system (a network). In particular, some of the criteria most affecting the network selection are:

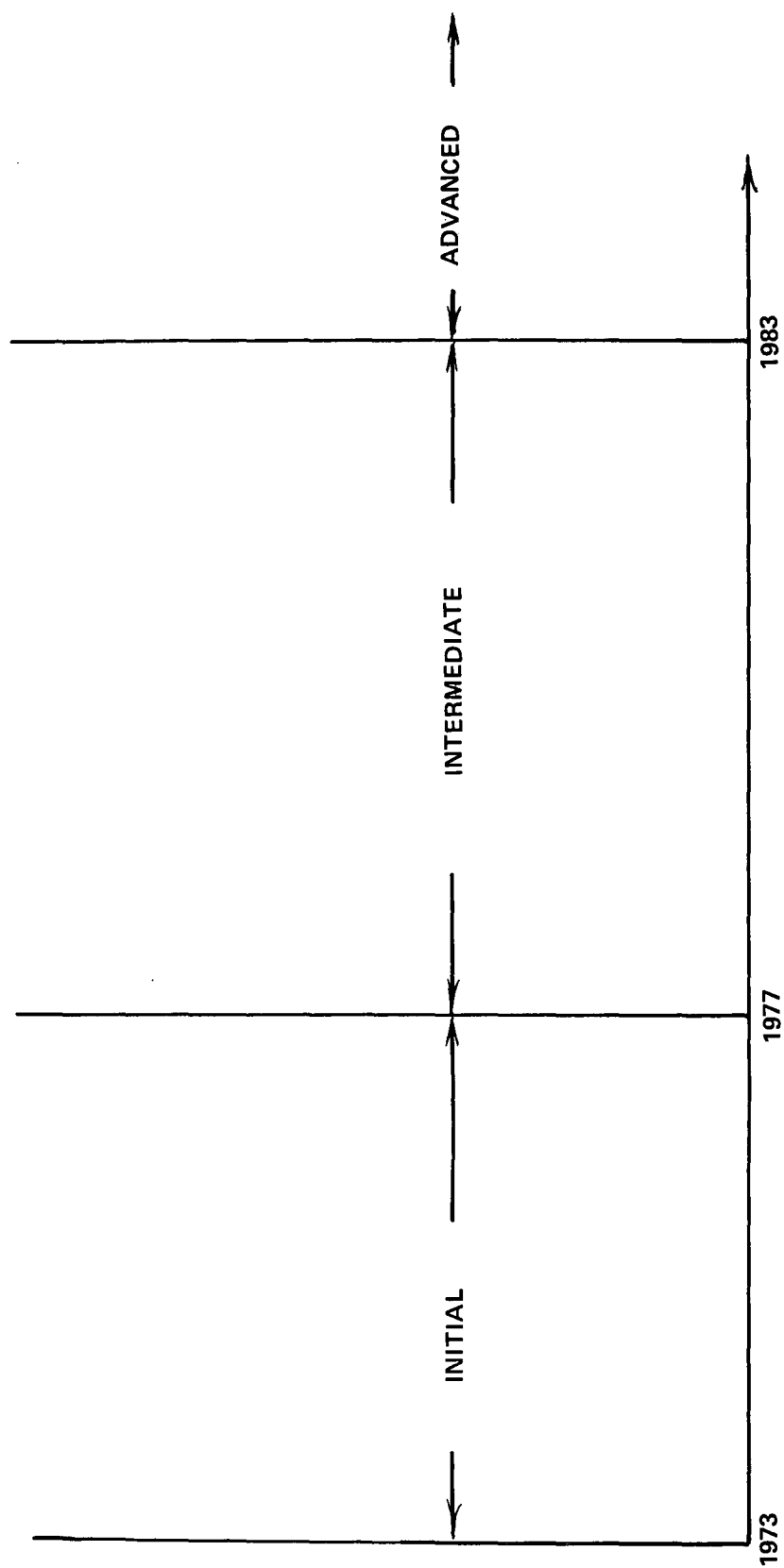


EXHIBIT 6-3: PHASES OF SYSTEM DEVELOPMENT

- evolutionary potential - A modular network system can grow in scope and capability by simply adding additional centers into the network.
- adaptability - A network system can respond to a changing environment by adding or deleting centers, by altering the communication links, or by shifting the functional emphasis of any center.
- user satisfaction - By having centers in each state, responsive to the state governments, the system can provide services tailored to the local user community. It is anticipated that during the early phases of system operation some of the major users will be state and local planning agencies who can be better served by state and local centers connected into a national network than by a centralized federal system.

These and other criteria argue strongly for a decentralized network of centers distributed around the country, each highly responsive to a given user community.

6.2.1.1 Hierarchical Structure

The ERISTAR system is organized into a hierarchical structure related to geographic subdivisions. There are centers at four levels in the hierarchy:

- national
- regional (multi-state)
- state
- local (sub-state)

Not all levels need actually be present in all parts of the system. For example, some states may wish to omit the local centers and have a single state center. Other states may wish to omit the state centers and deal directly with a joint regional center.

The national center has cognizance over information pertaining to the nation as a whole, while each of the lower levels is concerned with information pertaining to its own sphere of interest. The communications network allows a user to access the system at whatever point is most convenient for him, while the response to his request is developed at the center appropriate to that request.

The regional centers provide an intermediate level of aggregation between the state centers and the national center. The regions could be constructed in many useful ways. One possible division of the nation into regions is shown in Exhibit 6-5. Each regional center should be appropriately located within the region.

NATIONAL

STATE

LOCAL

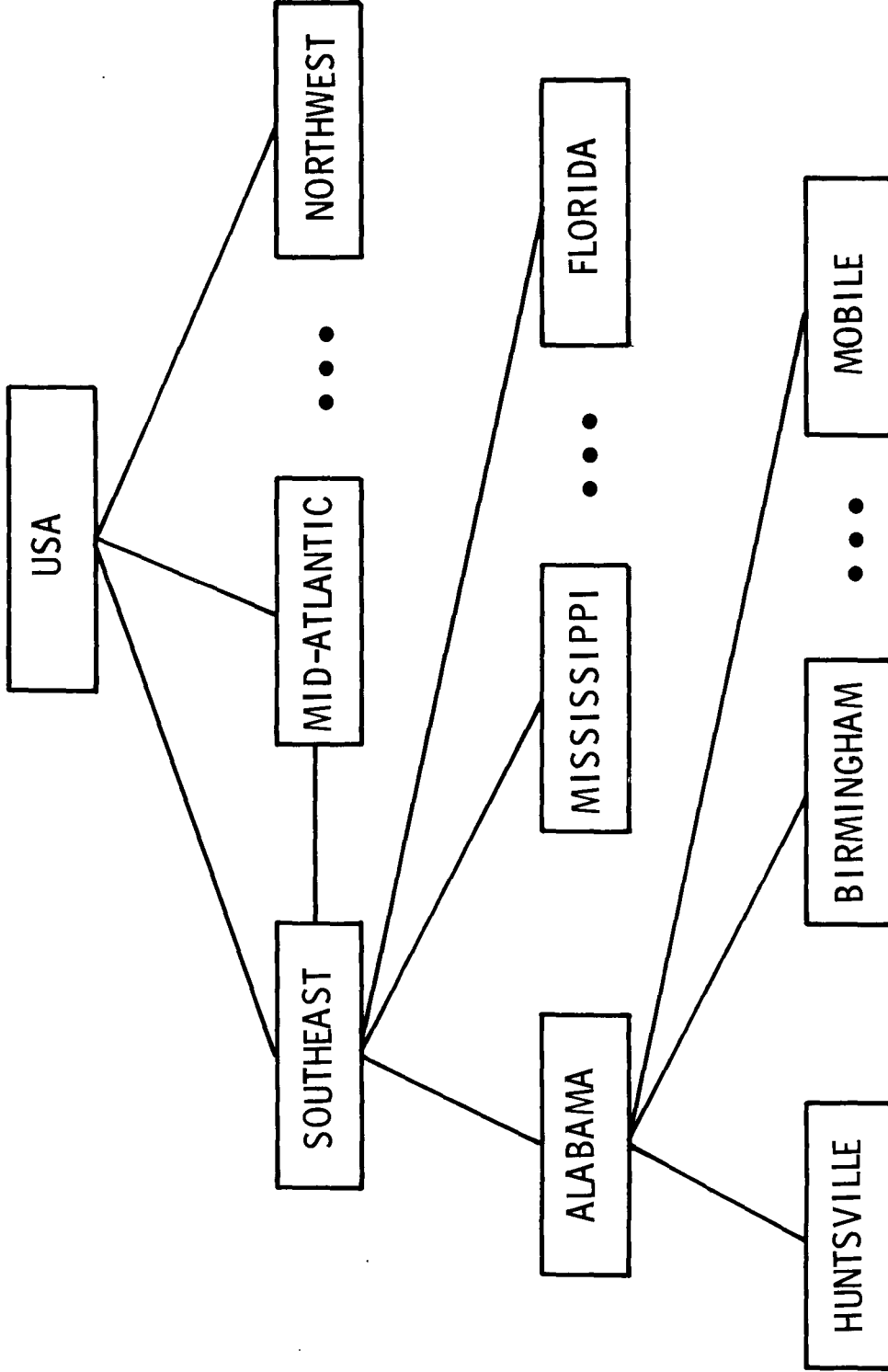


EXHIBIT 6-4: HIERARCHICAL STRUCTURE

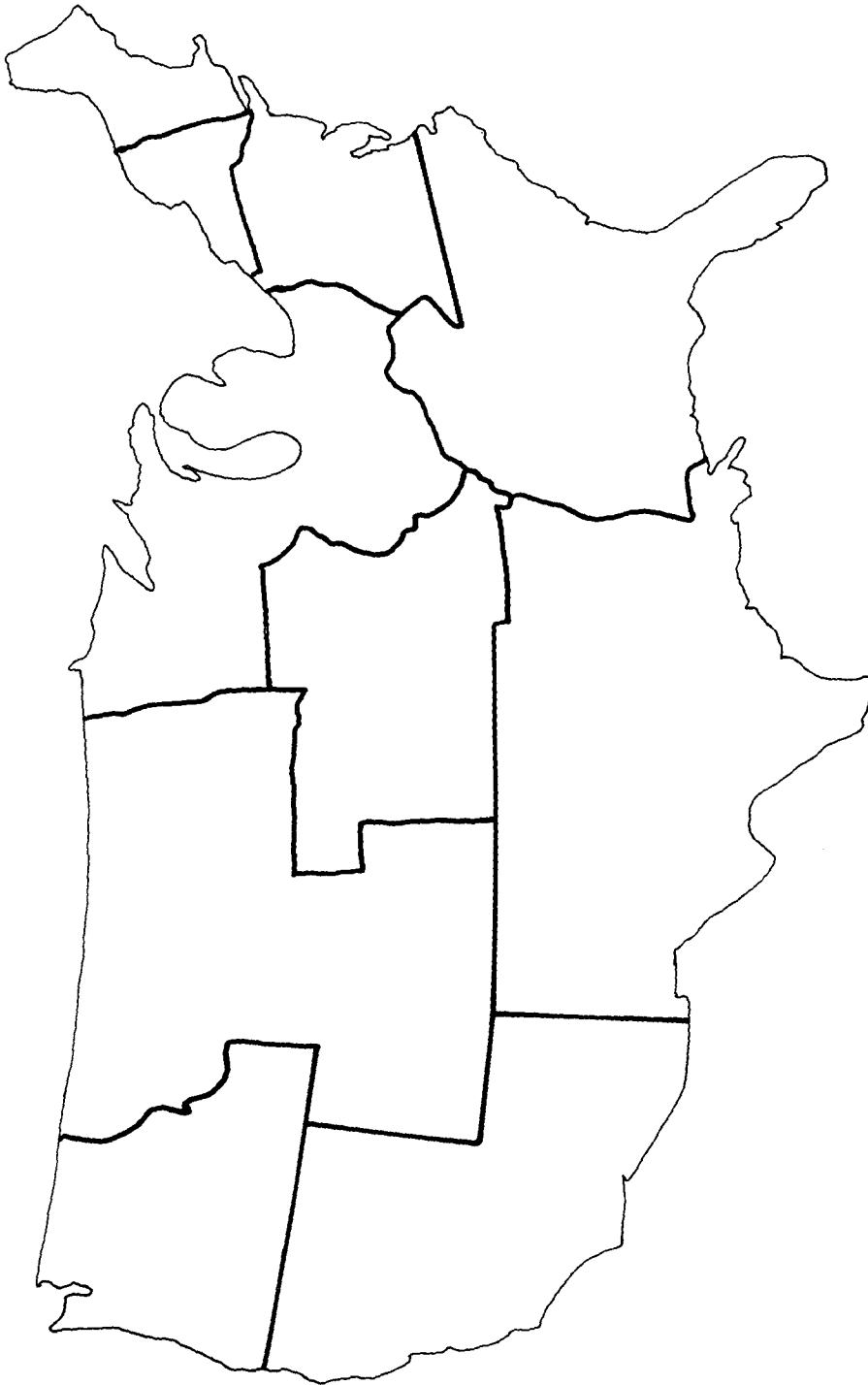


EXHIBIT 6-5: REGIONAL DIVISIONS

The state centers are in an especially advantageous position for providing information to decision-making bodies in the state government. They can also serve the general public with information particularly relevant to the state.

At a later stage in the development of ERISTAR, the local centers will provide points of contact for the "man-in-the-street" users and district and municipal agencies and organizations.

6.2.1.2 Administration

ERISTAR is planned as a joint federal/state undertaking. The national center and regional will be administered by the federal government, while the state centers will be administered by the states themselves. The regional/state interfaces will be the responsibility of commissions, some of whose members are appointed by the states in the region and some by the federal government. When local centers are introduced into the system, they will be locally administered, with guidance and counsel from the state.

An alternative management structure which is compatible with the hierarchical network design is to have all levels under federal administration as is done, for example, with the Soil Conservation Service. A detailed evaluation of the two alternatives was given in Chapter 5.

6.2.2 ERISTAR Network Centers

Each center in the ERISTAR network will have the same general form and functions irrespective of its position in the hierarchy. However, not all functions will be emphasized to the same degree in all centers. In large centers a single function may be carried out by many staff members and involve the use of complex hardware and software. In small centers several functions may be performed by a single person with a minimum requirement for supporting facilities.

A network center is divided into three operational divisions

- User Services
- Information Analysis and Processing
- Center and Network Operations

An outline of the functions performed in each division together with the types of personnel involved and the requirements for center management are shown in Exhibit 6-6. The external and internal interfaces for the centers are illustrated by Exhibit 6-7.

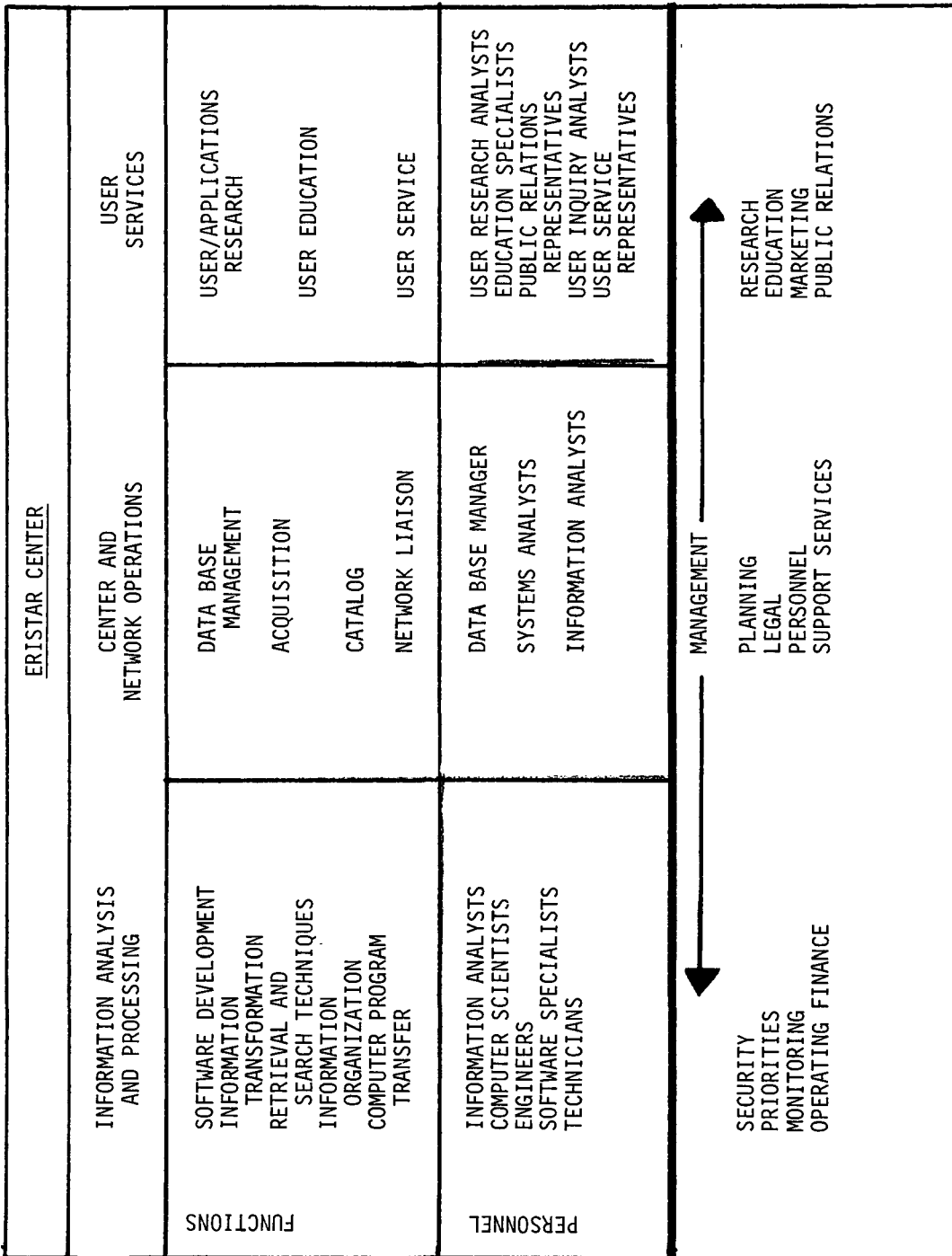


EXHIBIT 6-6: ERISTAR CENTER FUNCTIONS AND PERSONNEL

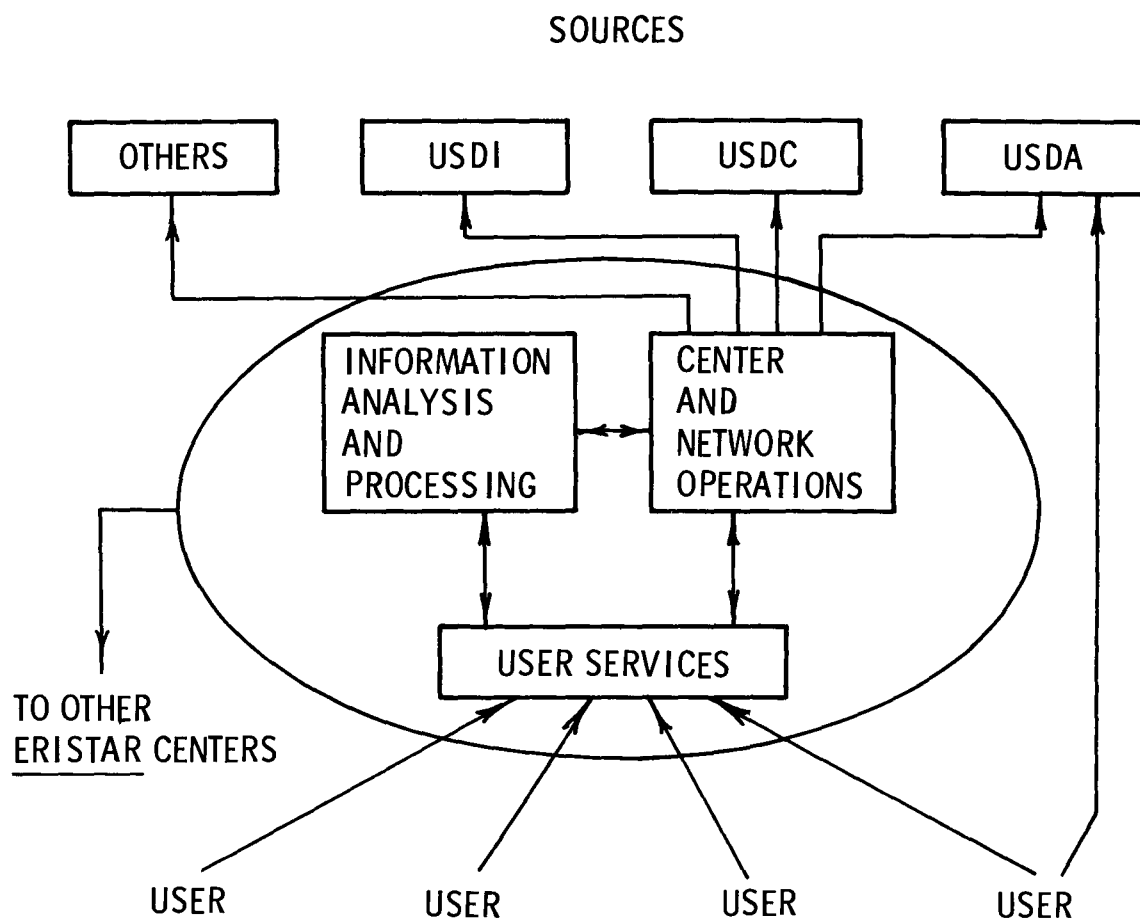


EXHIBIT 6-7: ERISTAR CENTER DIVISIONS AND INTERFACES

6.2.2.1 User Services Division

The User Services Division in ERISTAR will be made up of three departments organized on a functional basis. The departments are:

- User/Applications Research
- User Education
- User Service.

The User/Applications Research Department will be charged with identifying the members of potential user communities and specifying system output criteria (control, format, display media, etc.) to satisfy the user's needs. This department must respond to changes in the system environment due to the development of new technologies, the recognition of new problems, and the emergence of new users. These operations will be the responsibility of a User Research Analyst.

A potential user of information will access ERISTAR through the User Service Department. The service center representative will deal with a wide range of user capabilities. Proper analysis will determine the types of information required, the sources to be utilized, appropriate output formats, and distribution channels. The user query may be processed at the center or it may be referred to other services of the ERISTAR system. The desired data/information, in useable formats, will be distributed through appropriate channels to the users as a final service of the center. During the entire process, interaction with the user is maintained to assure satisfaction with the final output.

Relating the services of ERISTAR to users and potential users will be initiated by creating an awareness of the system through the public relations services. An awareness of ERISTAR will be directed to business enterprises, educational institutions, governmental agencies and, most importantly, the individual.

The public relations service will attempt to stimulate earth resource information awareness by directing persuasive communications to the potential user communities. The instruments of creating awareness--advertising, personal communications, promotion, and publicity--have separate and overlapping capabilities. These tasks fall in the area of operations of the Public Relations Representative.

Once aware of ERISTAR, individuals or groups become potential users with varied capabilities. They must be educated and trained in detail about how the ERISTAR system operates, what types of services it provides, what type of data/information is available and how to obtain this information. Some researchers, planners, and investigators will need to receive varying degrees of training regarding the hardware, software, and network aspects of the ERISTAR system. For more explanations of the user services function, see both the case study described in section 4.3, above and the description of the actions which take place in an attempt to satisfy the information needs of an ERISTAR user in section 6.2.4 below.

The User Education Department may develop a specialized program to handle only the training of ERISTAR users, or it may utilize the existing education facilities of universities, governmental agencies, information centers, and the like. Carrying out this educational operation will require considerable interfacing with all components of the ERISTAR system.

6.2.2.2 Information Analysis and Processing Division

This section deals with the development of the analysis and processing requirements profile of a typical ERISTAR center. The word typical should be emphasized since it is fully expected that these functions will vary in importance and number from center to center.

The principal functions that are visualized for information analysis and processing in the ERISTAR centers are:

- Software Development
- Information Transformation
 - Image processing
 - Inference procedures
 - Enhancement
 - Compression & reduction
 - Simulation and modeling
 - Display techniques
 - Photogrammetry and cartography
- Retrieval and Search Techniques
- Information Organization
 - Content analysis of documents & imagery
 - Standardization
 - Indexing
- Computer Program Transfer

Software Development will be primarily for specialized applications. Operational software will be developed by the communications and information technology support facilities and then distributed to the centers. This is essential if compatibility is to be maintained.

The Information Transformation functions indicated above reduce information to a form useful for the user. Image processing techniques are necessary to handle satellite and airplane photography. Inference procedures deal with the analysis of data in order to predict and analyze events. Enhancement of data is the highlighting of certain aspects of these data in order to satisfy a specific requirement for information. Compression and reduction techniques deal with the removal of irrelevant detail. Simulation and modeling, as envisioned here, consists primarily of keeping and updating models which are developed elsewhere (e.g., in

the IACs). It is not expected that the ERISTAR*centers will do much simulation or model development. Display techniques will play a central role in presenting information to the user in its most meaningful manner. Photogrammetry and cartography deal with the production and analysis of photos and maps of a specialized nature, which are not produced by the appropriate IAC. This function need not necessarily be located in the ERISTAR centers. The centers need only be responsible for seeing that they are produced to satisfy specific requests.

Retrieval and Search Techniques play a central role in the operation of the ERISTAR center concept. Although many of the retrieval functions will be operational, it is expected that each center will have its own data storage requirements and will therefore need the provision to develop its own retrieval and search techniques for particular applications.

The Information Organization function is self-explanatory. Most of this function, except for very specialized requirements, will fall under the scope of systems operations.

The Computer Program Transfer function is perhaps the most important function in terms of maintaining system compatibility. It is well recognized that transferring software from system to system presents many difficulties due to differences in hardware and computer operating systems. This function will be dedicated primarily to overseeing the transfer of programs from center to center.

The principal personnel required to carry out the analysis and processing functions of the ERISTAR centers are as follows:

- Information Analysts
- Computer Scientists
- Engineers
- Software Specialists
- Technicians

Information analysts are individuals with a multidisciplinary background in earth resources-oriented fields, tempered with a background in statistics, mathematics and computer science. Their job will be that of analyzing and interpreting information at all levels. It should be pointed out that, at this time, people with this type of background are virtually non-existent. It is anticipated that, as the need develops, some of our universities will establish curricula in this and related areas.

*The abbreviation IAPD will represent this Information Analysis and Processing Division throughout the remainder of this report.

The role of computer scientists in the ERISTAR centers will be extremely varied in scope. Their activities will include hardware and software specialties as well as considerable interaction with the information analysts in the analysis and interpretation function.

Engineers will be required in ERISTAR centers because of their varied backgrounds and versatility. The engineering disciplines most likely to be relevant to the operation of these centers will be electrical, industrial, and environmental engineering.

Software specialists will be support personnel. Their functions will range from routine programming to operating system maintenance.

The role of technicians in an ERISTAR center is straightforward. Their function will be primarily that of technical support and routine maintenance.

6.2.2.3 Center and Network Operations Division

The principal functions of the Center and Network Operations Division (C&NOD) are

- acquisition and management of the locally-maintained data base
- communications and liaison within the network.

The C&NOD is responsible for the library and computer center operations as well as for the establishment of interfaces and working relationships with the various source agencies and information analysis centers.

6.2.2.3.1 Information Acquisition

Since the ERISTAR System is not charged with the original acquisition and measurement functions in collecting data, but rather depends upon other agencies to perform that role, an ERISTAR center acquires its necessary information from external information analysis centers and other data centers and programs. A complete discussion of the requirements and methods for acquisition of information from the source agencies was given in Chapter 2.

6.2.2.3.2 Data Base Management

It is envisioned that the majority of subject-oriented basic data and information will be maintained external to the network of ERISTAR centers. Still, each center must have immediately available certain high-volume items for which many requests are received, and also some highly processed multi-subject information for which additional requests are anticipated. The exact extent of the data base to be managed will vary from center to center, but the function will always exist to some degree.

The information in the data base will be stored in a variety of forms, some of which will require cataloging, indexing and retrieval procedures similar to those of a standard library. Other information will be maintained by a computer in machine-readable form.

In the latter case the choice of a particular file structure for representing the information is an important consideration. Generalized data base management systems have become available in recent years which allow for the introduction of a new data base with a minimum of programming and implementation problems. A detailed analysis of nine such systems was made in the CODASYL Feature Analysis Report [3] and general specifications for future data base management systems were given in the CODASYL Data Base Task Group Report [4].

The ERISTAR network centers may use a generalized data base management system which is created as an ERISTAR project or one already in existence may be adapted to the ERISTAR needs. Alternatively the data base management may be effected through special purpose programs written in high level languages which contain many of the necessary features, such as COBOL or PL/I.

6.2.2.3.3 Communications and Network Liaison

An information management system dedicated to the principle of avoiding where possible the replication of files resident within other systems implies some rather difficult problems in system interfacing and data transmission. The Resource and Land Information (RALI) proposal of the U. S. Department of the Interior [5] contains this principle as an integral concept, just as ERISTAR does.

Extensive computer networks have been established on many university campuses and in some cases such as the Triangle Universities Computing Center in North Carolina a single large computer regularly converses with smaller computers at a number of distant locations. The ARPA network [6] has shown the feasibility of having several quite different computers linked into a network for sharing information and computing capabilities.

But the transmission of digitized data will not be the only communications function of the C&NOD. Printed page facsimile and imagery transmission will also be an important aspect, as will verbal communication with personnel of other centers. The establishment of standards and procedures for communication and the provision of liaison functions to insure smooth working relationships with other centers and external agencies are all part of the duties of the Center and Network Operations Division.

6.2.2.4 ERISTAR Center Management

A management structure has been developed for an ERISTAR Center in order to assure that it performs its functions as efficiently and effectively

as possible. The Center functions described in the preceding sections (6.2.2.1 - 6.2.2.3) must be managed as well as the standard functions common to all businesses and agencies (e.g., Research, Legal, Planning, Finance, Personnel and Support Services). The management sets policy to control the operation of the Center and monitors the Center to be certain that the policy is implemented and followed.

Organizational charts of the management structure are shown in Exhibits 5-6 through 5-9.

The general manager is responsible for the total operation of the Center. It is his duty to decide which of the functional responsibilities he will delegate (and to whom he will delegate them) and which of the functional responsibilities he will assign to himself. It is suggested that the general manager be personally responsible for the political and diplomatic aspects of interfacing his Center with other centers within ERISTAR and other information centers outside ERISTAR. The Center general manager should also be directly responsible for setting Center policy with regard to user and source priorities as well as user and source data security. The general manager will, of course, give guidance to his staff with regard to delegated responsibilities and be certain that they are performing well.

The management structure of an ERISTAR Center has been planned so that functions are stressed rather than personnel. This has been done to allow a single function to be managed by several persons in a large center with a high volume of use and several functions to be managed by one person in a small center with a low volume of use.

6.2.3 Agencies and Centers External to the Network

The conceptual design for ERISTAR partitions the functions of the information system into those housed within the network centers and those residing in federal, state, and private agencies external to the network. This partition is crucial to the ERISTAR concept, for the principal data acquisition, analysis, and processing capability will remain in these external agencies. Key features of the ERISTAR operation are (1) that it make maximum use of existing earth resources information activities and (2) that it not duplicate activities on-going in outside centers and agencies nor attempt to draw such activities into the network centers. Fundamental to the ERISTAR concept is the idea that the network centers be in active communication with these on-going external activities without exercising administrative control over them. This section treats the existing information programs in those agencies and centers external to the ERISTAR network. It refines the concept of an Information Analysis Center, from the descriptions provided in Chapters 2 and 3, and relates the IAC to the operation of agencies and centers outside the ERISTAR network.

6.2.3.1 Existing Earth Resources Information Programs

There are many experimental and operational information programs related to earth resources and the environment throughout the United States. With few exceptions, notably the EROS (Earth Resources Observation System) program in the U. S. Department of the Interior and the NASA ERTS (Earth Resources Technology Satellite) program, these existing programs are confined either to a level in the governmental hierarchy (national, regional, state, local) or to a disciplinary area such as geology, hydrology, agriculture or oceanography. These existing programs acquire data and information on a routine, continuous basis from space based, aircraft-based, or ground-based sources. They perform well-established analysis and processing functions, produce standard data products (such as photographs, microform, printed documents, maps, and magnetic tapes and other machine-readable forms) and disseminate these data products to those readily identifiable users who customarily avail themselves of that information system. The operational plan for ERISTAR would modify this operation minimally, as far as any particular information program is concerned. The same acquisition, processing, and dissemination activities in each existing program would continue. The dissemination process would be supplemented through utilization of an appropriate set of ERISTAR network centers. Moreover, the ERISTAR centers would provide an additional level of processing, such as combining and digesting inputs from a number of existing agencies into a coherent information product.

In order to visualize the panorama of existing earth resource information programs, it might be convenient to consider again the n-dimensional profile discussed in section 3.1.2.1. Existing systems can be categorized along the following dimensions:

- ° Level in administrative hierarchy (national, regional, state, local)
- ° Discipline or subject area (geology, agriculture/forestry, hydrology, atmosphere, oceanography, etc.)
- ° Source-base (satellite, aircraft, ground)

Other dimensions could be considered, such as primary storage mode (shelf documents, computer, specimens and samples, etc.), but the three cited above will suffice for the subsequent discussion.

The NASA Data Processing Facility (NDPF) at Goddard Space Flight Center, Greenbelt, Maryland, is an existing information system established to provide data and information from the Earth Resources Technology Satellites (ERTS) to principal investigators, government agencies, and other approved users. This system would occupy a row of cells in the matrix at the national level for the hierarchical dimension, the satellite source, and spanning all disciplines. The NDPF is an example of an

external center to which the national ERISTAR center would be connected. While NDPF would provide substantial inputs to the ERISTAR system, it would remain under the administrative control of NASA. The Earth Resources Research Data Facility at Manned Spacecraft Center in Houston, Texas, is another such example. This center would occupy a row of cells at national, regional, state, and district levels, aircraft and ground sources, and spanning all disciplines. As with NDPF, it would remain under the administrative control of NASA while connecting operationally with both the national ERISTAR center, the regional center which includes Texas, the Texas state center, and the district center which includes southeast Texas. An example of an external agency or center with regional influence is the Environmental Information Systems Office at the Oak Ridge National Laboratory in Oak Ridge, Tennessee. At the state level, the Agricultural Extension Service at Auburn University in Auburn, Alabama, is an example of an existing agency that will interface with state and local ERISTAR centers in Alabama.

It would require an encyclopedia to completely catalog and describe existing earth resources information systems in the United States. In Chapter 2 these aspects of source specification have been examined in detail. The important point here, however, is to give examples of those existing systems external to the ERISTAR centers that would no doubt interface very strongly with the proposed system. Two things should be clear in viewing these examples: (1) these existing systems can provide expertise within their own areas that ERISTAR could scarcely hope to acquire on its own; and (2) it is absolutely necessary that ERISTAR tap this enormous reservoir of existing capability. The proposed ERISTAR system is so structured that it interfaces with these existing programs so as to take maximum advantage of their source and analytical capabilities.

6.2.3.2 Information Analysis Centers

The mechanism that is provided in ERISTAR to enable it to interface with existing agencies and centers is to establish a liaison with an Information Analysis Center (IAC) in each of these agencies where they exist. ERISTAR should foster the creation of IACs where they do not. The concept of an Information Analysis Center is well documented, and its definition is stated in section 1.3.1. Some of the more important characteristics of an IAC are:

- ° "The key activities are the analysis, interpretation, synthesis, evaluation and repackaging of information for the purpose of enabling users better to assimilate the information or numerical data of a specific field.
- ° An information analysis center uses subject specialists to perform the analysis, evaluation, or synthesis.

- An information analysis center produces new, evaluated information in the form of critical reviews, state-of-the-art monographs, or data compilations and usually provides substantive, evaluated responses to queries.
- An information analysis center provides assistance to a community of users and not just to 'in-house' personnel." [2]

Section 3.5.4 in this report provides additional description of an IAC. Many earth resources information analysis centers are in operation now, although some of them would not recognize themselves by that name. The acceptance of the IAC as a significant functional entity is growing rapidly within the technical community and promises to have a major effect on future information programs.

The key features of the IAC in interfacing with ERISTAR are as follows: (1) it will be housed in and operated by a particular external agency at a single location; (2) it will represent a concentration of information, knowledge, and expertise in a particular earth resources subject area; and (3) it will be connected to one or more ERISTAR centers through communications linkages. An IAC may be instituted within a particular agency to serve the ERISTAR network alone, but may also interact with other government and private agencies and centers not associated with an earth resources system. It will derive most of its funding from its own organization, but could be supported to some extent by contracts with ERISTAR. This is especially true of private agencies and universities. The IAC could use its own standard sources of data and information, or in certain instances operate upon data provided by an ERISTAR center. In almost all cases, however, data and information will flow from an IAC to an appropriate ERISTAR center before finding its way to a user.

6.2.3.3 Numerical Data Centers

Another class of external units that the ERISTAR network must communicate with are numerical data centers; typically these will be computerized data banks. Examples of these include the National Marine Data Inventory at the National Oceanographic Data Center (NODC) and the STORET program (System for Technical Data on Water Quality) of the Environmental Protection Agency.

Interfacing with such centers is made difficult by the wide variances in data storage formats, programs employed, and equipment used. In some cases an ERISTAR will go through an IAC in order to tap a data bank. Note that in some cases a numerical data center is co-located with an IAC. The NODC combines data center and IAC activities.

6.2.4 Overall Operation of the System

Perhaps the best approach to a description of the overall operation of ERISTAR is to consider a "typical user" of the system and follow, in a

general way, the actions which take place in attempting to satisfy his information needs.

The user first makes contact with the most convenient ERISTAR network center, no matter what the scope of his request. This establishes the "single point of contact" which is so important to making a system user-oriented. The center which he contacts may be at any level in the hierarchy. The User Services Department (USD) in the contacted center determines the scope of the request and communicates the request to the ERISTAR network center which has cognizance over the particular geographic area of interest. The cognizant center then has lead responsibility for satisfying the request.

If the request involves information for which many requests are received, or if it involves the result of a combination of information from several subject areas which has been previously developed and saved the response may be found in the data base of the network center. But more commonly the network center will need to contact outside sources of earth resources information (IACs, numerical data centers, or other activities). When the required information is obtained from the external sources, the additional analysis and processing is done which is necessary to combine the source information into the proper response to the request and to convert it into the correct form and format. The final product is communicated to the center originally contacted by the user. The USD then distributes the material to the user.

During this entire operation, interaction has taken place between

- the user and the USD of the contacted center,
- the IAPD of the lead center and the appropriate Information Analysis Centers or other sources, and possibly
- directly between the user and the source.

In this way the user may clarify his request and modify it if necessary as he gains information. The interaction may be accomplished by verbal communication with humans or by the use of interactive terminals connected into the computer complexes.

6.3 DEVELOPMENT PLAN

A major strength of the modular network design is that the system can function in a useful manner with considerably less than its full complexity and capability. Although it is anticipated that the system will evolve in scope and capability in a nearly continuous fashion, for planning purposes the development has been divided into three phases - initial, intermediate and advanced. The advanced design, which includes the full hierarchical structure, complex real-time communication links, and coverage of all the earth resources subject areas has been described in section 6.2. In section 6.3.1 and 6.3.2 are described the initial and intermediate phases of development. A prototype implementation of a portion of the initial system is introduced in section 6.3.3.

6.3.1 Initial System

An initial version of the ERISTAR system can be established almost immediately by making use of existing state and federal information programs and establishing simplified state-level centers to provide a referral service. The national center will serve essentially in an advisory and co-ordinating capacity.

The primary users of the initial system may be state and local governmental agencies with decision-making responsibilities in the earth resources areas. The state-level ERISTAR center will maintain a complete directory of agencies and centers which can provide information and analytical expertise in the various earth resources subject areas. Detailed descriptions of the services available and instructions for accessing each source will also be maintained by the state center. The communication links in the system can be simply the existing telephone and mail services.

This rather simple creation of a system of state referral centers, loosely connected into a network co-ordinated by a national center, can immediately make existing programs more accessible to the users. The uncertainty, time delays, and attendant frustration which accompanies current efforts by the uninitiated to locate and utilize existing information programs will be greatly alleviated. At the same time, the cornerstone of a comprehensive, highly capable information system will be laid.

6.3.2 Intermediate System

At an intermediate point in the ERISTAR system development, the hierarchical structure can be expanded to include regional centers and a complete national center. The communications network can be upgraded to include digital data links, video and facsimile transmission, and various human-oriented terminal devices. More complete interfacing and interaction with the external information analysis centers and

other source agencies will take place and a degree of standardization will have been achieved. The scope of the system can be enlarged by establishing connections with additional subject-oriented source centers.

The primary users of the intermediate system will be agencies and organizations of all types, both governmental and private. The ERISTAR network centers will still perform referral services in the case of some of the more complex requests, but by this time will be able to collect and distribute most of the information directly to the user.

In the intermediate phase, all the major elements of the advanced system except the local centers will be present, but each will have a reduced capability and the complete interactive communications facility will not have been realized.

6.3.3 Prototype

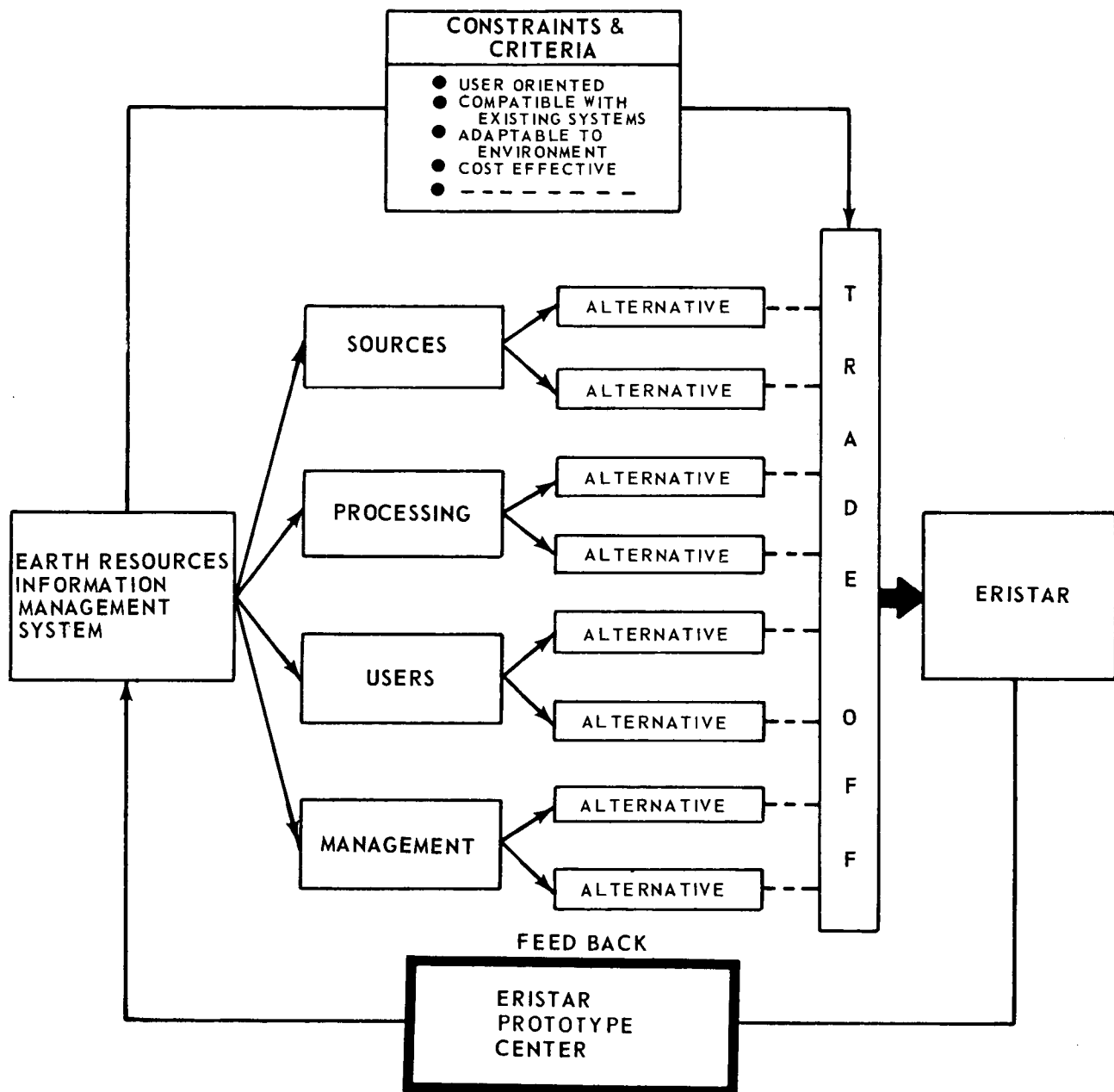
Prior to approval of the ERISTAR concept and establishment of the initial phase of the system, a prototype or model system can be developed in a limited geographic area which will demonstrate the feasibility of the approach and prove the utility of the system in an operational environment. The outline of the prototype together with specific recommendations for implementation are given in Chapter 7.

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7. IMPLEMENTATION



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7.1 PROTOTYPE ERISTAR CONCEPT AND EVOLUTION

This chapter discusses the development of a prototype ERISTAR system in the Southeastern United States.

7.1.1 National ERISTAR Network and Support Facilities

The national ERISTAR network is displayed in Exhibit 7-2. The ERISTAR network consists of a national ERISTAR Center and regional ERISTAR Centers administered by the Federal government and state ERISTAR Centers administered by the respective state governments. Exhibit 7-3 shows the ERISTAR regional network for the Southeast and depicts the regional center in Atlanta with a model state ERISTAR Center in Huntsville, Alabama. This chapter discusses the mechanism for developing a prototype state ERISTAR Center that will serve as a model for the southeastern region and ultimately the United States. No consideration is given to which agency or agencies will administer the Federal part of the system though the compatibility of ERISTAR with the RALI program of The Department of Interior is noted [1]. The emphasis is on development of the state networks. It is recognized that this network and its activities will require technical support that will encompass research, development, application and analysis in the areas of communications and information technology. Thus, the concept of communication and information technology support facilities is developed as an addition to the ERISTAR conceptual design. These facilities, linked by a support network, would be a part of and contained within existing federal centers and laboratories and industrial and state laboratories where efforts are being devoted to:

- "The design of special instruments to acquire data (e.g., remote sensing research)
- The use of special-purpose machines to both acquire the data (e.g., map digitizers) and to display the results of data retrievals (e.g., X-Y plotters, color TV screens, etc.)
- The use of computers to store, retrieve, model and synthesize the data
- The development of operational computer programs for use by all regional centers [1]."

The RALI proposal [1] outlined the previously enumerated functions as being those to be conducted by a "National Information Technology Office". In this study, it is proposed that existing activities of federal, state and private industrial laboratories constitute the network of communications and information technology support facilities.

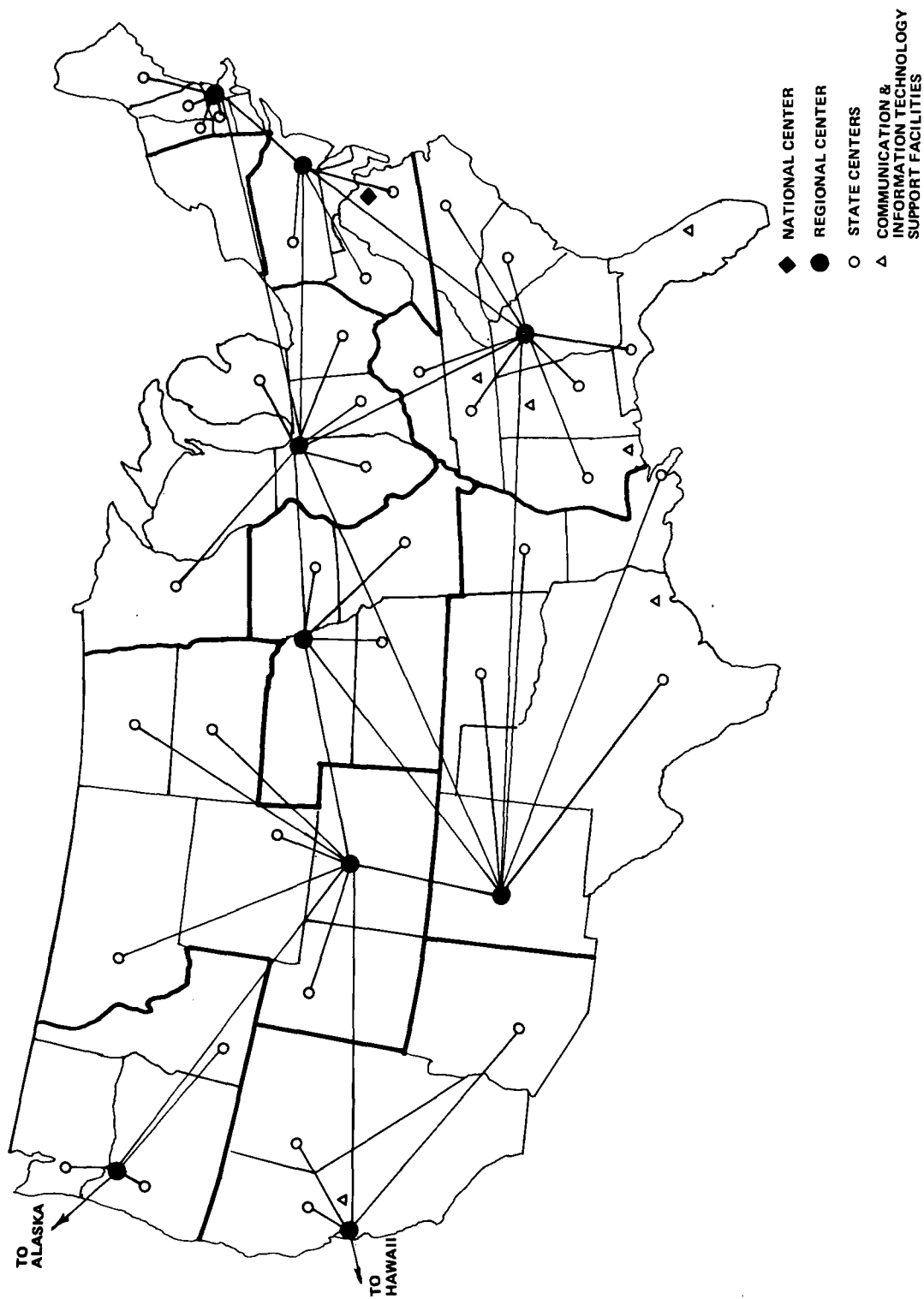


EXHIBIT 7-2: ERISTAR NATIONAL NETWORK - THE ULTIMATE OBJECTIVE

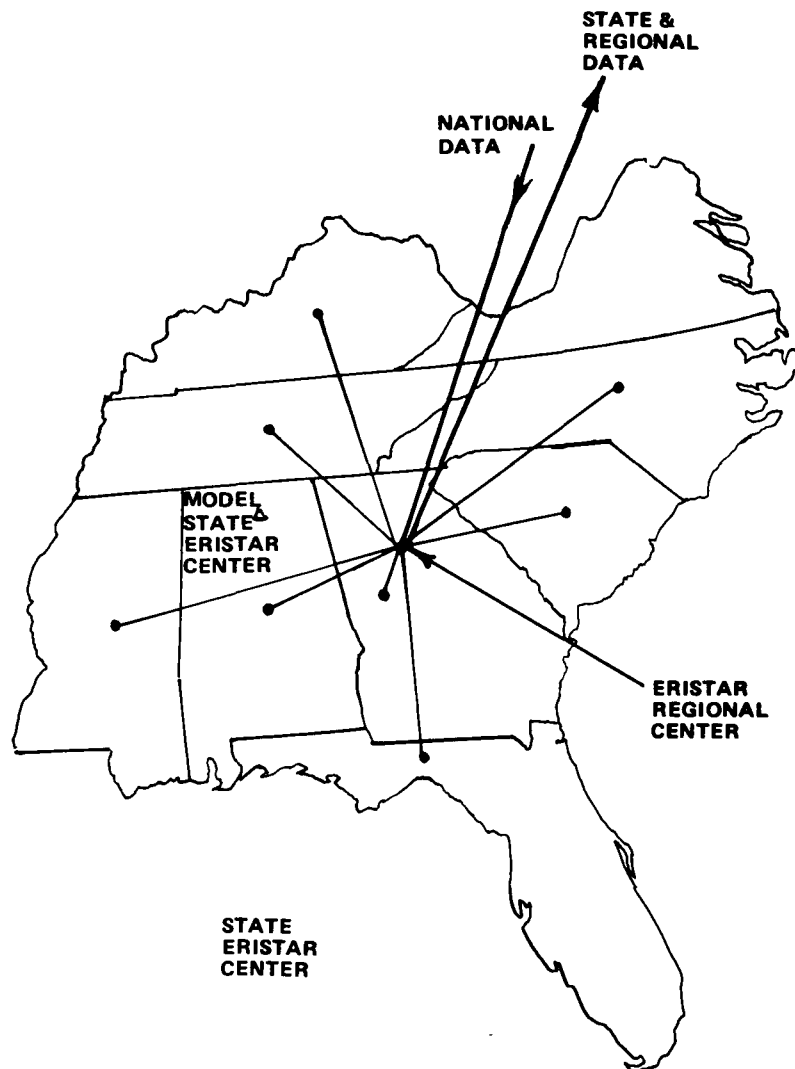


EXHIBIT 7-3: SOUTH EASTERN REGIONAL ERISTAR NETWORK

The ERISTAR network thus serves a number of national needs. The system provides:

- Information vital to the management and use of earth resources
- A ready market and proving ground for new technology that ultimately should be reflected in the national economy
- Opportunities, encouragement and assistance for free-enterprise interaction since the system represents a framework and focal point for a national concentration on the management and use of earth resources information
- Integration of activities currently underway in the area of earth resources.

It is seen that the ERISTAR network and the supporting facilities network constitute a blend of federal and state governments and free enterprise to provide earth resources information for decision makers at all levels.

7.1.2 Regional ERISTAR Networks

Exhibit 7-2 depicts the various regional networks. These regional divisions are in keeping with the President's comments made to the press on March 27, 1969, and May 21, 1969, in a press release, "The Regional Boundaries for Certain Federal Agencies", but it should be realized that there are other regional divisions of the United States employed by federal agencies consistent with their missions which are inconsistent with the division boundaries shown here. The U. S. National Atlas [2] displays these divisions and a comparison of the divisions in the Atlas with Exhibit 7-2 demonstrates these inconsistencies. Exhibit 7-3 depicts the regional center for the Southeastern region in Atlanta which is consistent with the RALI Program, *but it should be pointed out that at this time no final decision as to the regional center is suggested or has been made by the ERISTAR designers.*

The model ERISTAR Center would be located at the George C. Marshall Space Flight Center (MSFC). This ERISTAR Center would serve as a basis for the establishment of ERISTAR Centers in all interested states, especially those in the southeastern region. It is envisioned that a model center or centers would be in existence for the life of the ERISTAR System to serve as a test bed for innovation and a training facility. The model center is discussed in further detail in section 7.2.

The development of the model center, the first state center and subsequent state centers resulting in a regional ERISTAR System

is envisioned to occur in 3 phases. The fourth phase would be the full ERISTAR System. (The word phase here is used differently than in Chapter 6). These phases are depicted in Exhibits 7-4 and 7-5 and are discussed in the following sections.

7.1.3 Phase 1: Model State Network

7.1.3.1 Step 1: Model Network Center at MSFC

Exhibit 7-4 (Step 1) shows the state of Alabama as the candidate for the first state center with the model state ERISTAR Center at the George C. Marshall Space Flight Center. A solid line is used to indicate a strong line of communication to the Alabama Development Office in Montgomery and the State Committee on Earth Resources DATA discussed in 7.3.1.5. This line indicates that close liaison should exist between the Alabama Development Office, the Committee, and the appropriate MSFC personnel during the development of the ERISTAR Center. Similarly, solid lines are shown to represent close liaison with the other states in the southeastern region. This close liaison with the planning and development groups of the states should insure a general model center that is adaptive to each state's situation. The network structure for each state should reflect the needs and governmental character of the state.

The solid lines to the NASA Manned Spacecraft Center, the Mississippi Test Facility and other NASA centers indicate that the Model Center would require the cooperation of these centers and facilities. This cooperation would consist of developing mechanisms for inclusion of communications and information technology as well as experience in the development of the Model Center. This cooperation would also include the co-location of personnel from these other centers to insure the liaison and to promote the development of a truly representative model center. The solid lines to "other Federal Agencies" indicate the need for interactions, similar to the ones with NASA centers, to insure compatibility of the Model Center with the efforts of other agencies indicating the need to tap the technology, ideas, and relevant data banks of these agencies. Interactions with technical and professional societies, industry, and international groups are intended but not indicated by solid lines in the exhibit.

The dashed lines indicate that, in Step 1, lines of communication will be established with those state groups that constitute users of information from the Model Center as well as suppliers of information to the Model Center. There are numerous sources of data relevant to Alabama available in the state and external to the state. The Model Center will serve as the nerve center for these sources, translating the data from these sources into information as well as referring users to sources. The dashed lines indicate that the intent is for the Model Center plan to transfer these communications links to the state

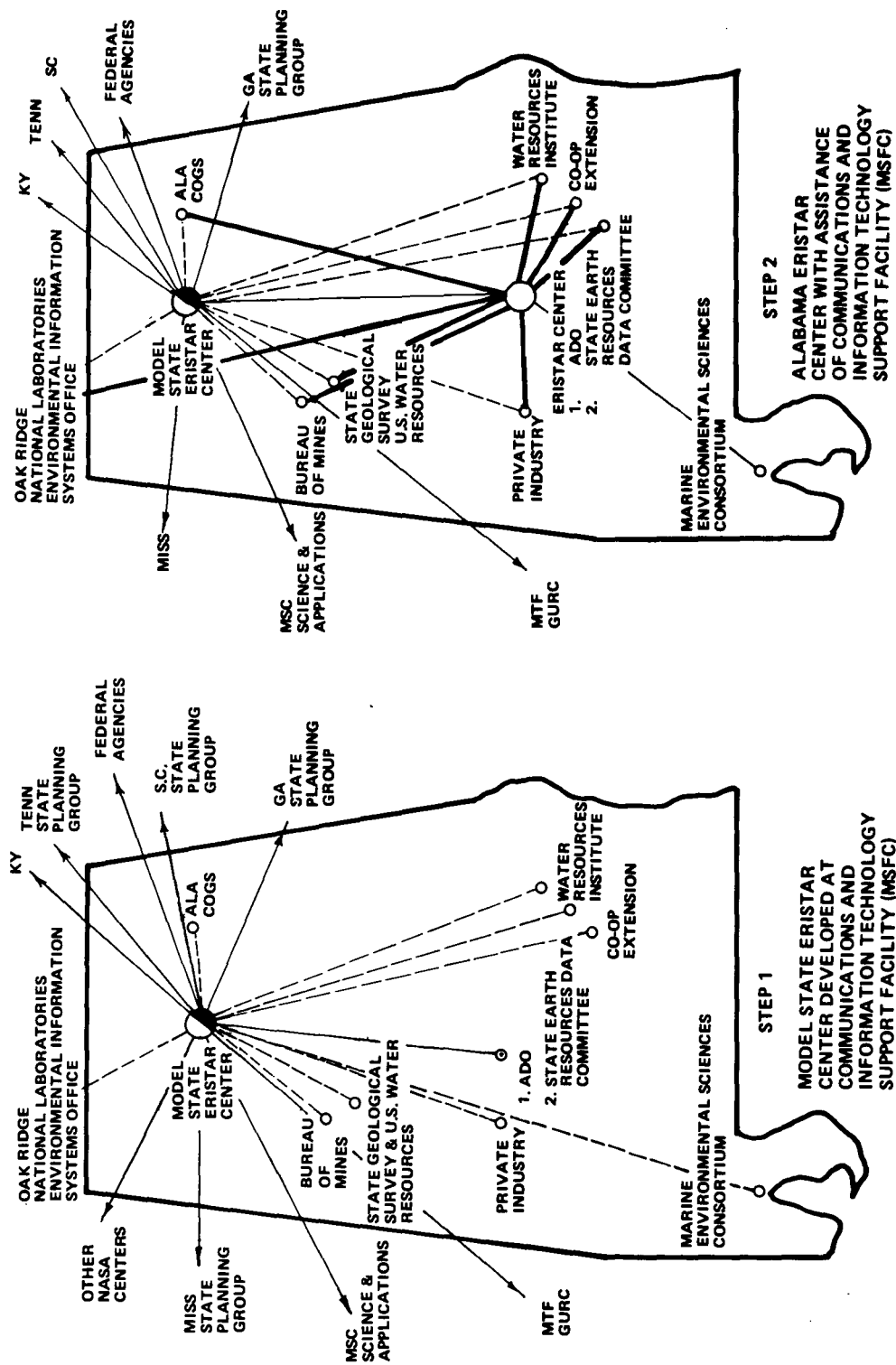


EXHIBIT 7-4: PHASE I FOR ESTABLISHING MODEL ERISTAR STATE CENTER & ALABAMA ERISTAR CENTER

ERISTAR Center in Montgomery as trained state ERISTAR Center personnel become available and as the state ERISTAR Center establishes compatibility with the ERISTAR communications net. It should be emphasized here that the importance of the Model Center is providing a "test case" for the state so that the development of the state center is smooth and conducive to establishing a sense of user confidence in the center. A poor start at the state level could be seriously detrimental not only to the network but also to national needs.

A specific example of a data source is the Environmental Information Systems Office (EISO) at the Oak Ridge National Laboratory. It represents a referral point by the Model Center and a source of data for analysis in the Model Center. EISO has been demonstrated to the ERISTAR planners [3] and proved to be a working, adaptable input to the Model Center and hence ultimately to the state ERISTAR Center.

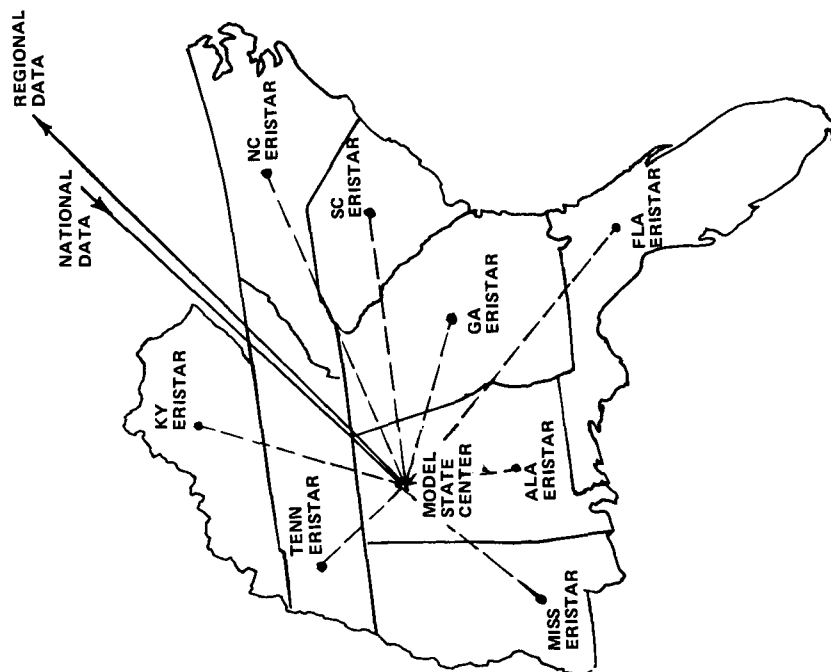
The selection of Alabama as the first state for a center is discussed later in this chapter as is the rationale for selecting the Marshall Center as the location of the Model Center. It should be pointed out that some interactions have already occurred between the Marshall Center and neighboring states with regard to earth resources. These interactions emphasize the differences in each state with respect to computer usage and systems. Computers will play a large role in the ERISTAR network and the Model Center will have to develop a means of rendering these various state systems compatible with the National ERISTAR System. Compatibility is a major problem since indiscriminate use of computer hardware and software can burden the state and federal networks with unnecessary and debilitating costs. Thus close liaison between the states and the proposed Model Center is essential.

7.1.3.2 Step 2: Transformation of Model Center Concept to Alabama

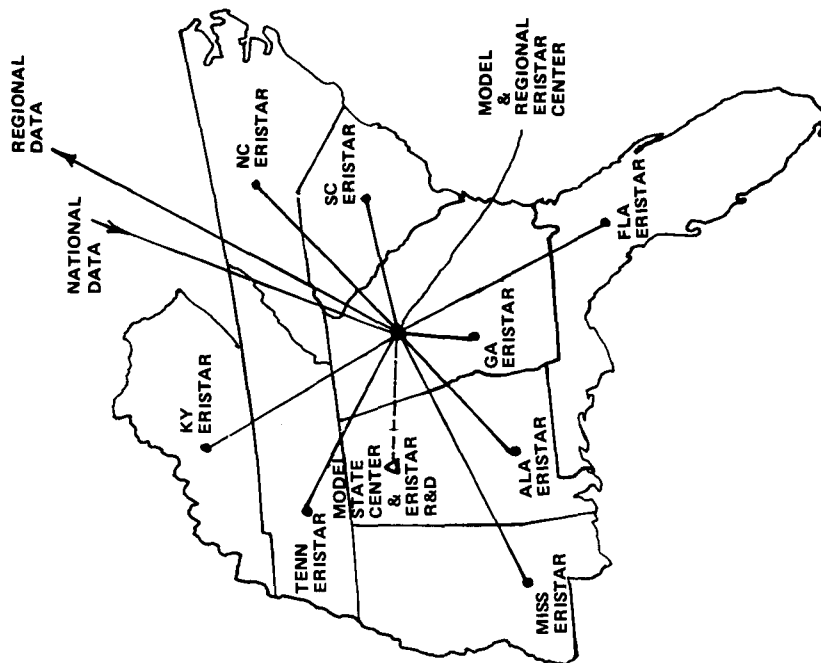
Exhibit 7-4 (Step 2) shows the network developed and the Model Center for Alabama transferred to full state control and administration. The state ERISTAR Center still maintains a close liaison with the Model Center at MSFC and depends on some data processing and analysis support at the Model Center. The Model Center now concentrates on developing ERISTAR Centers in other states in the region while continuing to function as a Model Regional Center.

7.1.4 Phase 2: State Centers in Southeastern Region Established

In the prototype ERISTAR depicted in Exhibit 7-5 (Phase 2) the state systems are established and linked to the Model State Center which is acting coincidentally as a Model Regional Center. Data on state center operations are being analyzed. Communication systems and data bases are being tested and adjusted. Visitors from other states are observing the network operation.



PHASE 2
MODEL CENTER
DEVELOP ERISTAR CENTERS



PHASE 3
ESTABLISH REGIONAL
ERISTAR CENTER

EXHIBIT 7-5: PHASES 2 & 3 FOR ESTABLISHING MODEL REGIONAL ERISTAR SYSTEM

7.1.5 Phase 3: Regional Center Established

In exhibit 7-5 (Phase 3) a Regional Center is established in Atlanta. This center serves as an example for other regional ERISTAR centers. The original Model Center continues to function as a model and test center for integration of new communications and information management technology. The communication and information technology support facilities throughout the nation contribute new technologies to the ERISTAR System primarily through the Model and Regional Centers.

7.1.6 Phase 4: The ERISTAR System

At the completion of Phase 3 the National ERISTAR System will be in operation, effecting lines of communications to other countries and perhaps shaping an international network. The Federal agency or agencies responsible for the ERISTAR network must be identified long before that time, but exploratory steps can be taken now at the state level independent of the choice of sponsor of the whole system. Furthermore it should be emphasized that many states and agencies are already engaged in activities that point toward a national network such as ERISTAR. Large expenditures have been made in selected earth resources areas (e.g., water) by a number of agencies for communications and information processing, and application of technology in general to environmental problems. These efforts would be enhanced by the ERISTAR System.

7.1.7 Rationale for Evolution of the ERISTAR System

The rationale for evolution embodies several points. The most cogent is--a concept with national impact involving many disciplines, areas of interest, geographical and political concerns, and established agencies must be examined on a trial basis with a clear cut way to expand the experience gained from the trial case. The state level is a logical beginning point. A state poses a sufficiently complex political environment to test the system as a whole. Also, the state is an existing political entity rather than a hypothetical example. Furthermore the majority of federal programs to date appear to be "imposed" on the states; whereas here it is hoped the states will work in concert with federal agencies to develop a system directly useful to themselves and to the nation. This grass roots development must take place in complex problem areas, since the solutions will present additional complexities--complexities that are best understood by the problem solvers. Logically the more problem solvers there are, the more widespread the understanding of the solution.

The concept of development is shown in Exhibit 7-6. This exhibit reflects the fact that the ERISTAR designers have been working with several of the states in the southeast and so propose this concept of evolution on the basis of real world involvement. The authors

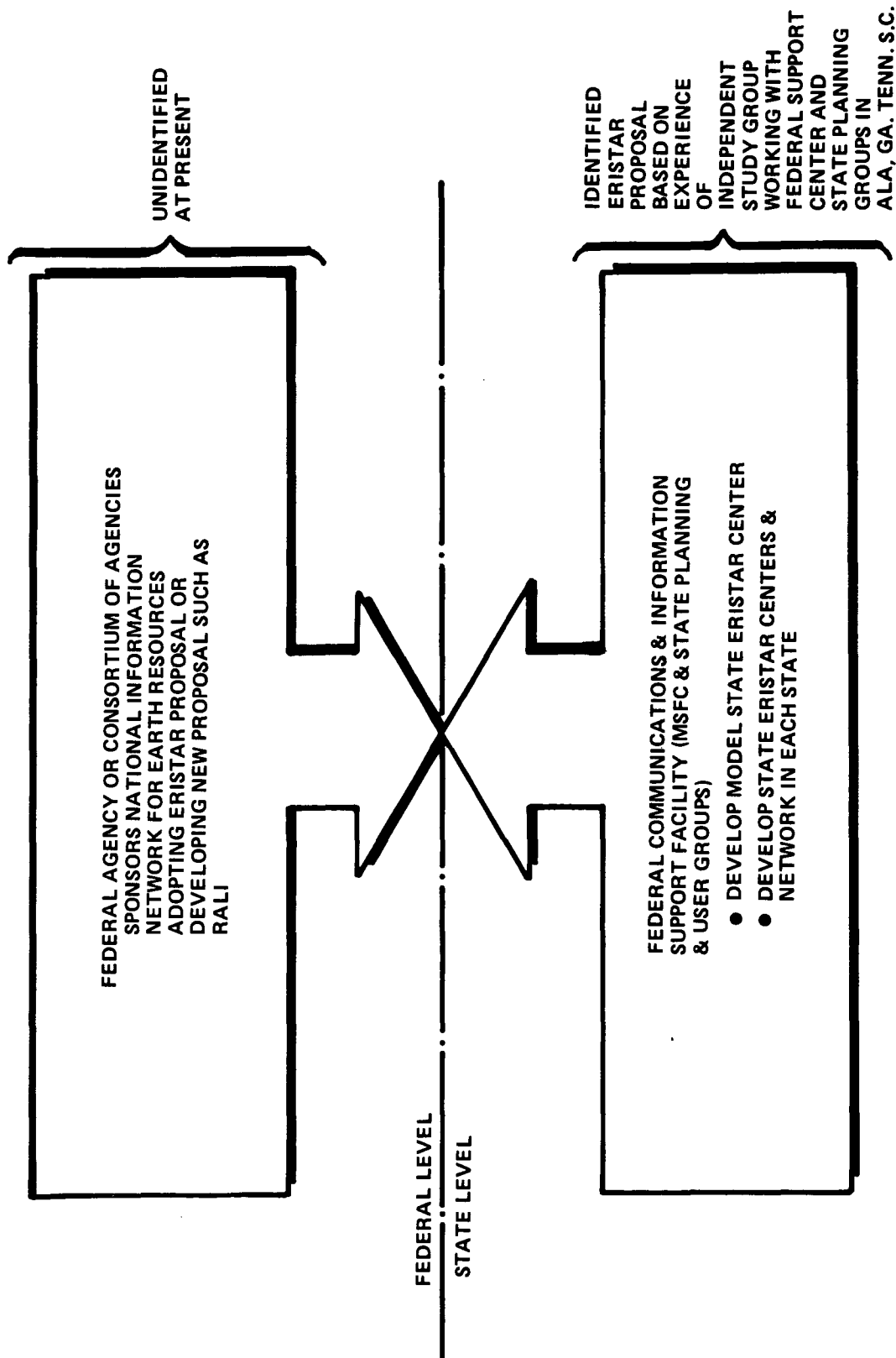


EXHIBIT 7-6: ERISTAR PROTOTYPE DEVELOPMENT CONCEPT

have talked with state planning groups and agencies as well as with Federal agencies. The evolutionary concept is based on these interactions.

The concept of a model center and a network of state centers is supported not only by the results of the ERISTAR study but also by the Council of State Governments report, Power to the States: Mobilizing Public Technology [4]. The report emphasizes the need for the Federal government to use federal facilities for demonstration and consulting purposes in the solution of state problems and the trend toward network interaction by the states is viewed favorably.

7.2 MODEL STATE ERISTAR CENTER

This section presents the Model State ERISTAR Center.

7.2.1 Center Function

The Model Center would have the following functions:

- Serve as a catalytic agent for the development of state ERISTAR Centers
- Consult with states on information management problems and center management
- Provide a focal point for collecting and developing communications and information technology as it applies to the ERISTAR network
- Assimilate and display information on data and information sources and information analysis activities
- Establish communications links with sources and users of data and information
- Analyze earth resources information requests to identify areas for information analysis activities
- Provide and coordinate educational activities on the ERISTAR system, earth resources, and associated information technology
- Develop a mechanism for interpretive interfaces with all levels of users for use by state ERISTAR centers
- Provide analytical procedures for the operation of state and regional ERISTAR centers rendering the system more cost effective and compatible with state policies and requirements

- ° Establish an equitable distribution of charges for services among the agencies and users
- ° Provide a marketing mechanism to be used by state ERISTAR centers.

These functions are intended to be encompassing as it is felt the Model State Center will serve as a test case for many parts of the system that will ultimately be handled in the national center and regional centers. One should also realize that these functions will vary in emphasis over time. Liaison with states, along with the education of the Model Center personnel to state needs and the accompanying education of users (and educators of users), is a high priority initial function that can be conducted while the Model Center is being developed.

Exhibit 7-7 represents the functions of the center and some typical interactions. The translation of these functions into a working Model Center will require follow-on effort to this report.

7.2.2 Elements of a Model Center

The various elements of a model center are consistent with those discussed in Chapters 5 and 6. The major elements are organization and personnel, information analysis and processing, center and network operations and user services. The following sections are devoted to discussing these elements and relating them to the proposed host, The George C. Marshall Space Flight Center, for the Model ERISTAR Center.

This discussion is followed by a statement of assets of the host and the assets of other centers and facilities to show the potential available for other model centers to be located at facilities such as the NASA Manned Spacecraft Center.

7.2.2.1 Organization of Personnel

It is proposed that the Model Center be developed under the auspices of the Environmental Applications Office, Science and Engineering, MSFC. The Model ERISTAR Center would have its own center general manager or director and staff. Exhibits 7-8, 7-9, 7-10, and 7-11 indicate the basic divisions of the center and associated functions. Initially an individual might serve in more than one capacity in the Model Center, with various divisions represented by one individual. However, it is anticipated that functional operation will come rapidly making staffing necessary.

Personnel should not be limited to NASA employees. Employees from other interested agencies should be co-located in the Model Center and be working members of the group. The Center Manager could well be an employee of the Department of the Interior, for example.

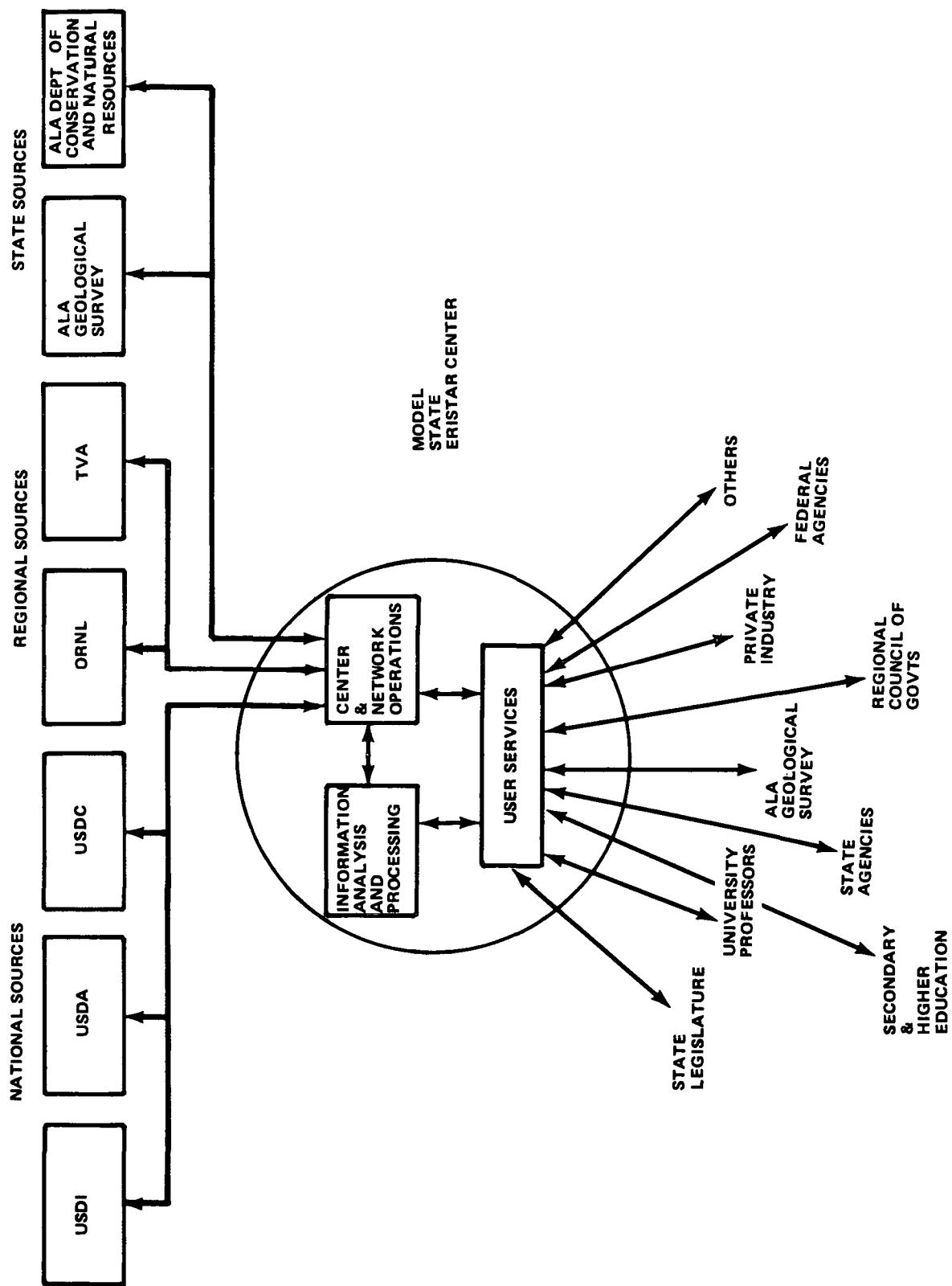


EXHIBIT 7-7: INTERACTIVE ELEMENTS OF MODEL STATE ERISTAR CENTER

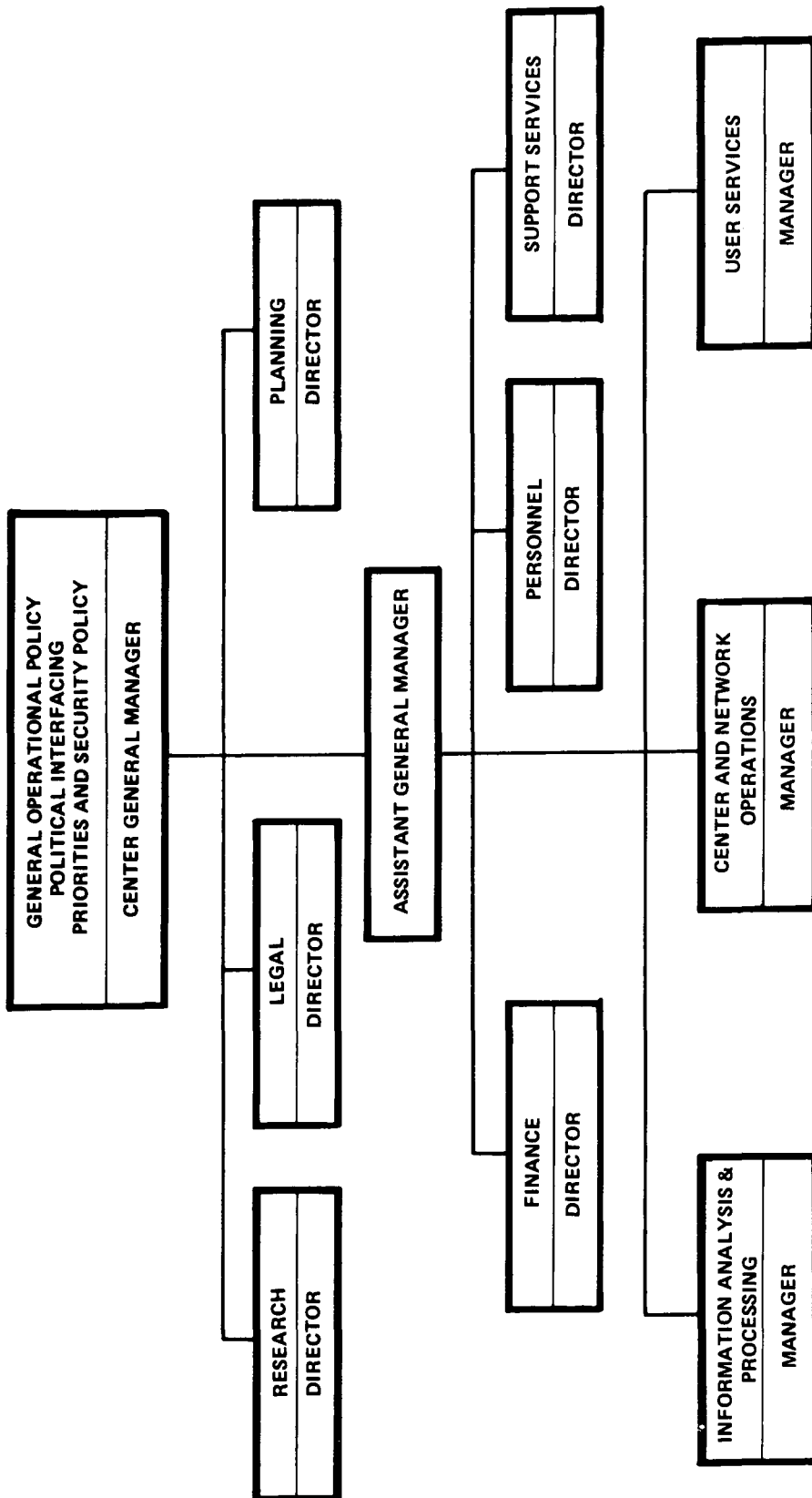


EXHIBIT 7-8: ERISTAR CENTER MANAGEMENT

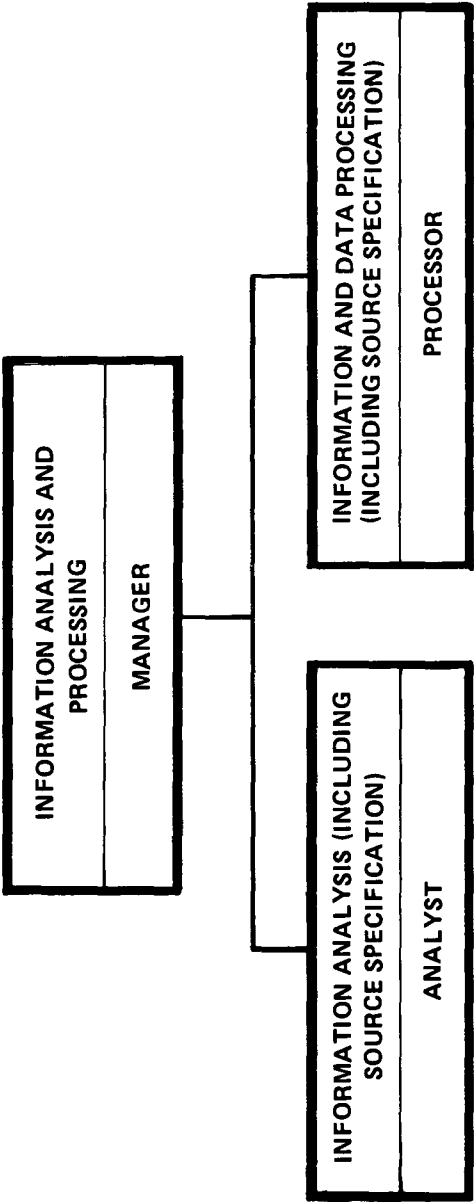


EXHIBIT 7-9: INFORMATION ANALYSIS AND PROCESSING MANAGEMENT

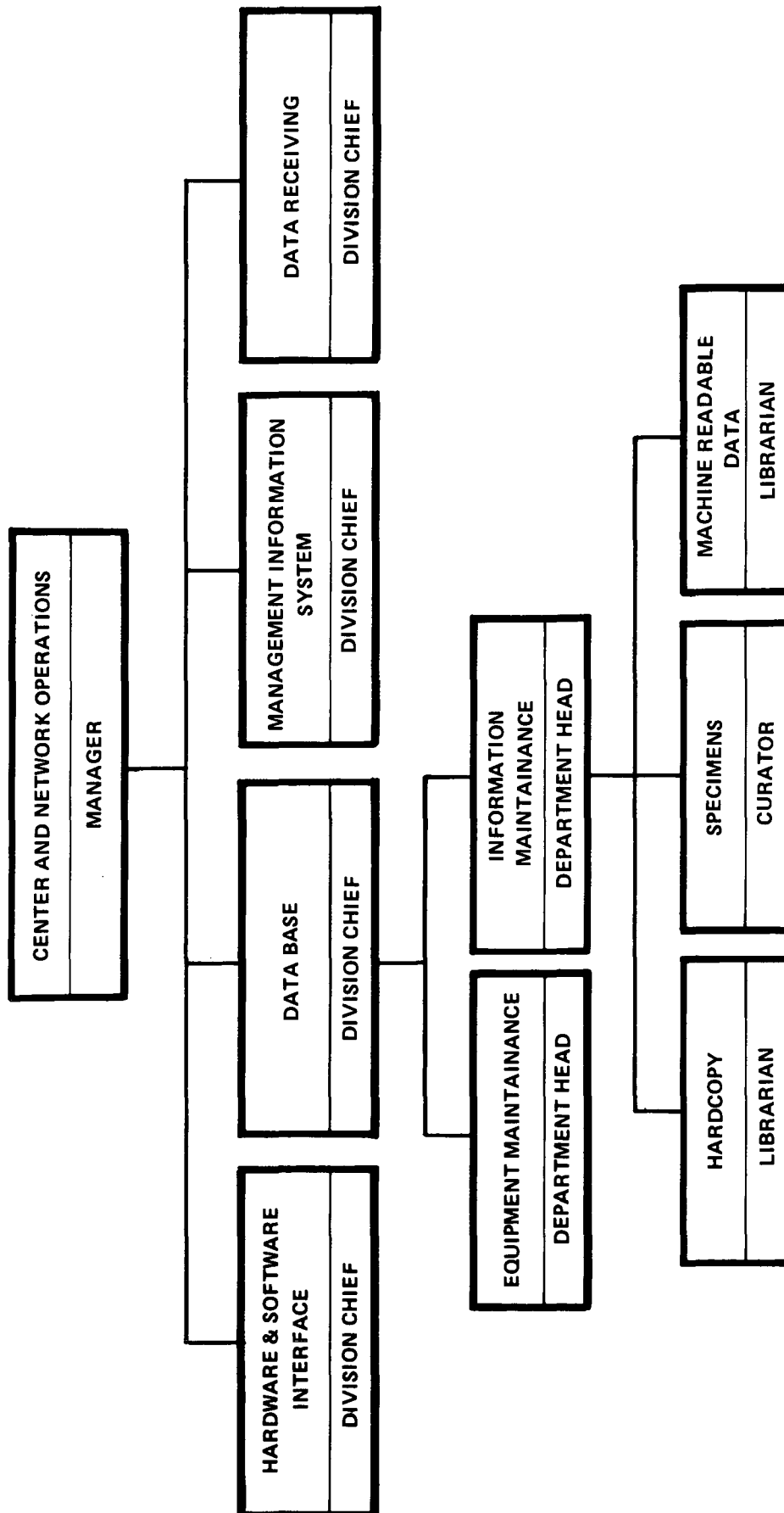


EXHIBIT 7-10: CENTER & NETWORK OPERATION MANAGEMENT

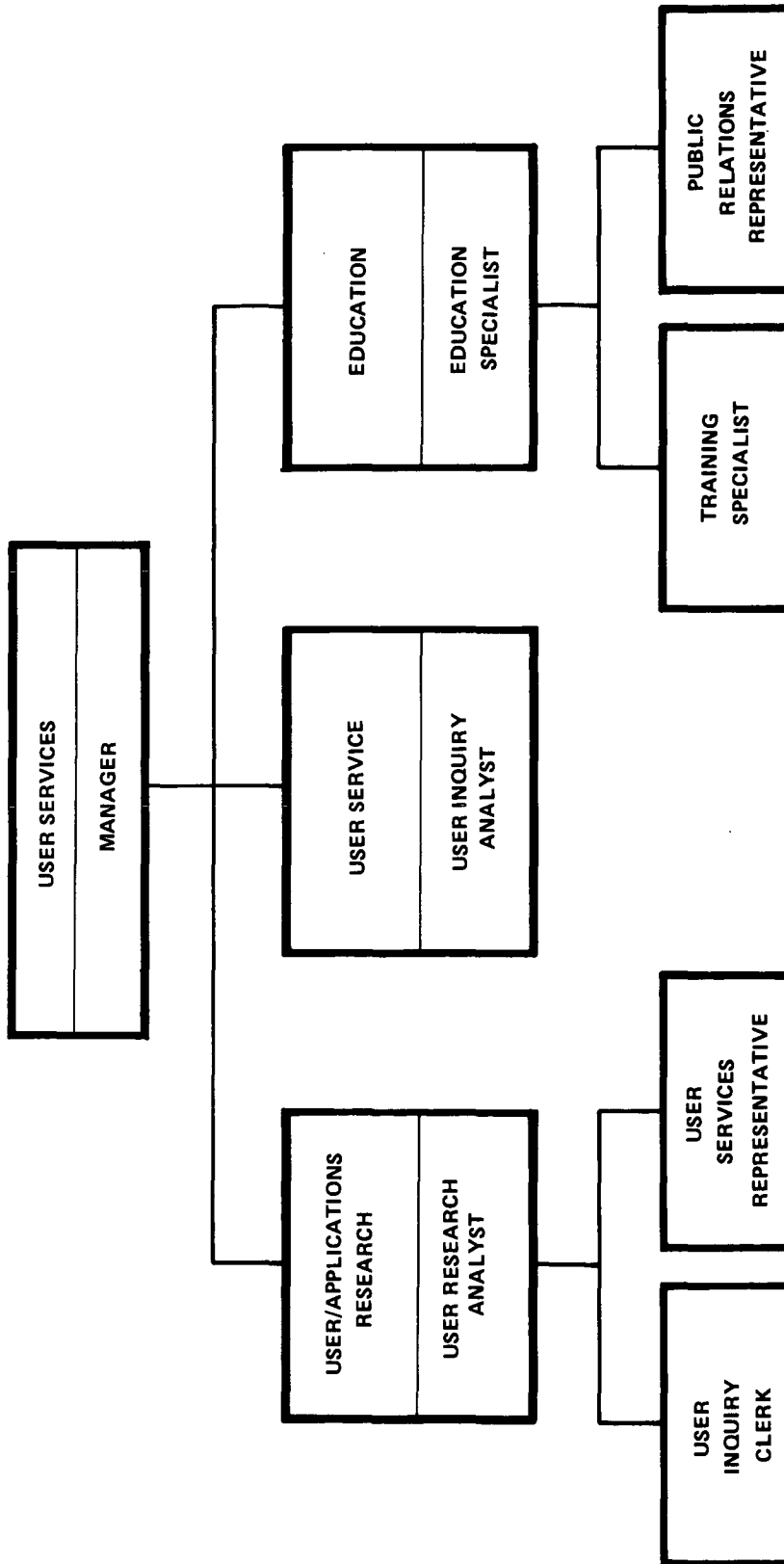


EXHIBIT 7-II: USER SERVICES MANAGEMENT

Personnel from state organizations should work side by side with the Model Center employees in the same roles to be occupied by the state workers when Step 2 of Exhibit 7-4 occurs. Some Model Center government employees should be detailed to work as observers in the state agencies for a period of time so that Model Center and state interactions are pursued on an equal basis.

7.2.2.2 Information Analysis and Processing

The Model State ERISTAR Center should make an assessment of information analysis activities and processing activities in earth resources. Activities at all NASA centers and other Federal and State agencies as well as university and private laboratories should be described with respect to scope and state of the art of processing and communications technology. This assessment should be followed by a study of anticipated user needs and NASA centers found to be strong in a particular aspect of analysis and processing should be asked to contribute these activities to the Model Center. The Model Center should determine which analysis and processing functions are compatible with state abilities in order to specify the processing and analysis functions to be carried out by Federal and State support facilities. It is conceivable that some states may perform an analysis function or processing function for a region or the nation. Many Information Analysis Centers (IAC) are already operated by the states.

The information analysis and processing function in the Model Center would involve, initially, considerable study but hopefully immediate efforts would be made to fulfill this function at least to a limited degree. The initial function would conceivably be less sophisticated than one might like but would insure center operations and study understanding.

7.2.2.3 Center and Network Operation

This element as Exhibit 7-10 indicates is concerned with determining data sources and insuring harmonious interface activities. Assimilating and making source information available is the key function of this element.

7.2.2.4 User Services

The user services arm of the Model Center will determine the success or failure of the Center as far as the public is concerned. Exhibit 7-11 shows what this element must do and coupling this exhibit with the chapter on users, the reader can group those functions in section 7.2.1 that belong to this element.

7.2.3 Communication and Information Technology Support Facility

The Marshall Space Flight Center is recommended as the host for the Model State ERISTAR Center. Other NASA Centers could well serve in this capacity. The Marshall Center has been designated as the lead NASA center in the area of communications and communications comprises a major element of the ERISTAR network. As the regional network grows, Marshall would ultimately become a Communications and Information Technology Support facility. The Marshall Center would continue to operate the Model ERISTAR Center as research for the ERISTAR System.

Other NASA Centers would operate as communications and information support facilities for the Model ERISTAR Center and the ultimate National ERISTAR System. Exhibit 7-12 illustrates the areas of competency in NASA as a whole. Some of the centers and their activities are:

- Mississippi Test Facility (MTF) of the Marshall Space Flight Center

MTF has demonstrated a way for interagency cooperation in the application of technology to environmental problems and could serve as an applications demonstration center. The Gulf Universities Research Consortium (GURC) is currently developing a natural resources data base [6] that would be used by the Model ERISTAR Center and operational state ERISTAR Centers. Furthermore, GURC would represent a possibility for developing information analysis operations since the Consortium represents a number of universities in the Gulf States and so can draw on subject area expertise.

- Manned Spacecraft Center

Its activities in all areas of gathering earth resources data and sharing these data with users are impressive [7]. The processing capability of MSC is advanced and represents a capability that the Model ERISTAR Center should use as an example. The Lunar Sciences Laboratory is another asset that should be considered. Personnel at MSC working in the area of earth resources have shown vision and imagination in their efforts and these efforts must continue.

- Goddard Space Flight Center

The extensive processing abilities of this center are documented well and represent a source for information on processing for the Model ERISTAR Center as well as a source of processed earth resources data.

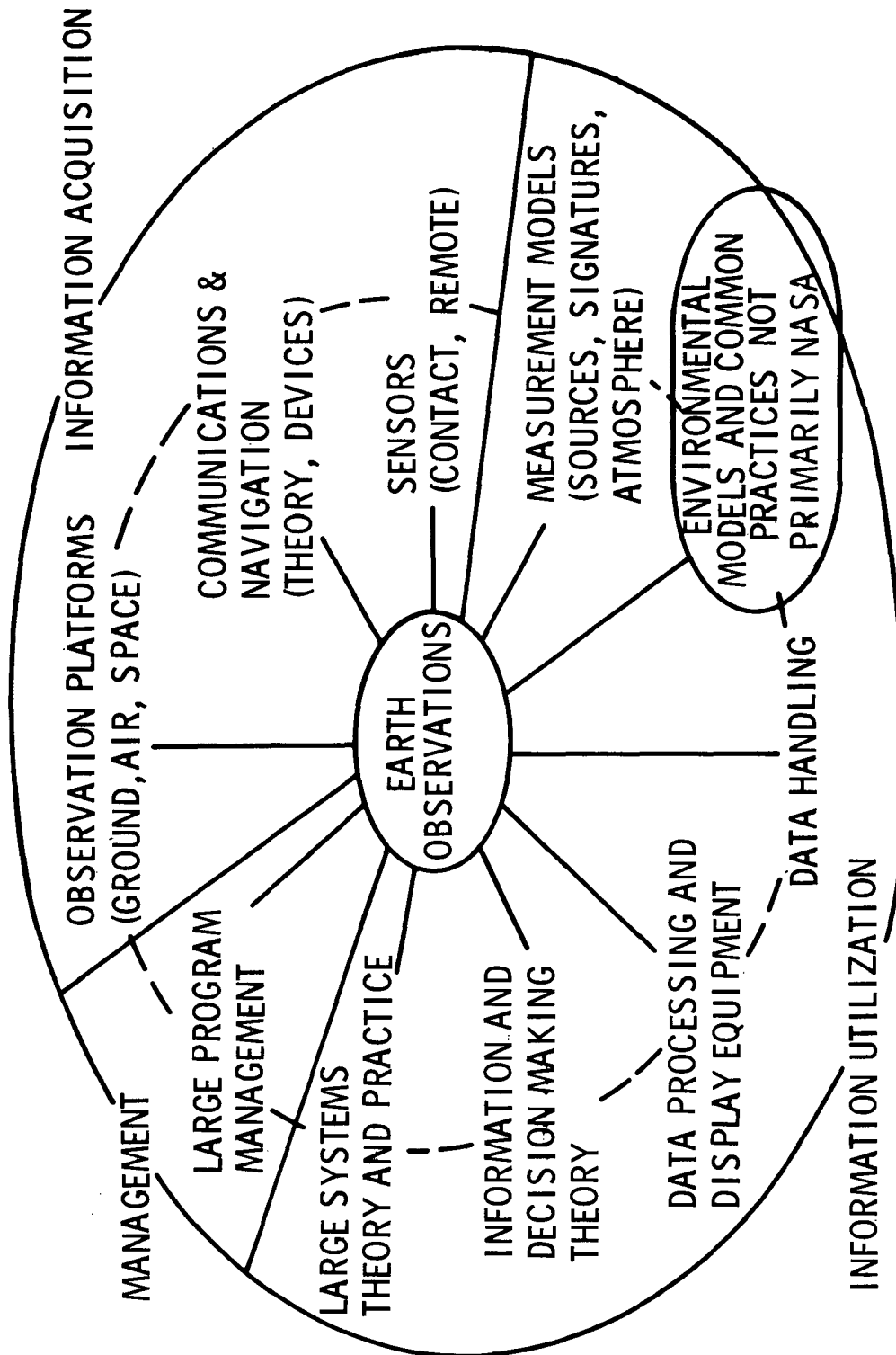


EXHIBIT 7-12: AREAS OF NASA COMPETENCE (5)

- Ames Research Center

The Ames Center has long been involved in biological and earth sciences analyses. The Center has sponsored a number of studies directly related to the rational utilization of earth resources and represents a substantial contribution to the Model ERISTAR Center. Furthermore, the lead role of this Center in the development of the ILLIAC IV should be mentioned.

- Langley Research Center

The Langley Center in Virginia has had a long standing interest in applying technology to the environment [8]. Several of the NASA/ASEE faculty programs have concentrated on earth resources and the Center is actively pursuing studies of the application of NASA technology to problems in the Chesapeake Bay and James River Estuary [9]. The Center management has a positive approach to these projects and it is anticipated that Langley would welcome the opportunity to serve as a Communications and Information Technology Support Facility for the ERISTAR System.

- Lewis Research Center

Some of the activities at NASA-Lewis Research Center (LERC) related to earth resources are coordinating activities between NASA-LERC and the State of Ohio/Battelle proposal for ERTS-A. Lewis is taking a lead in earth resources studies related to the water quality of the Lake Erie Region for the Environmental Protection Agency. The Lewis Center is modifying NASIS (NASA Aerospace Safety Information System) to handle information related to earth resources.

- Kennedy Space Center

The Kennedy Center is just beginning activities in earth resources that are heavily oriented to users at the state and county levels.

In summary, each of the NASA Centers and facilities should be a partner in the development of the Model State ERISTAR Center since each has interest, technology, capability and experience to offer.

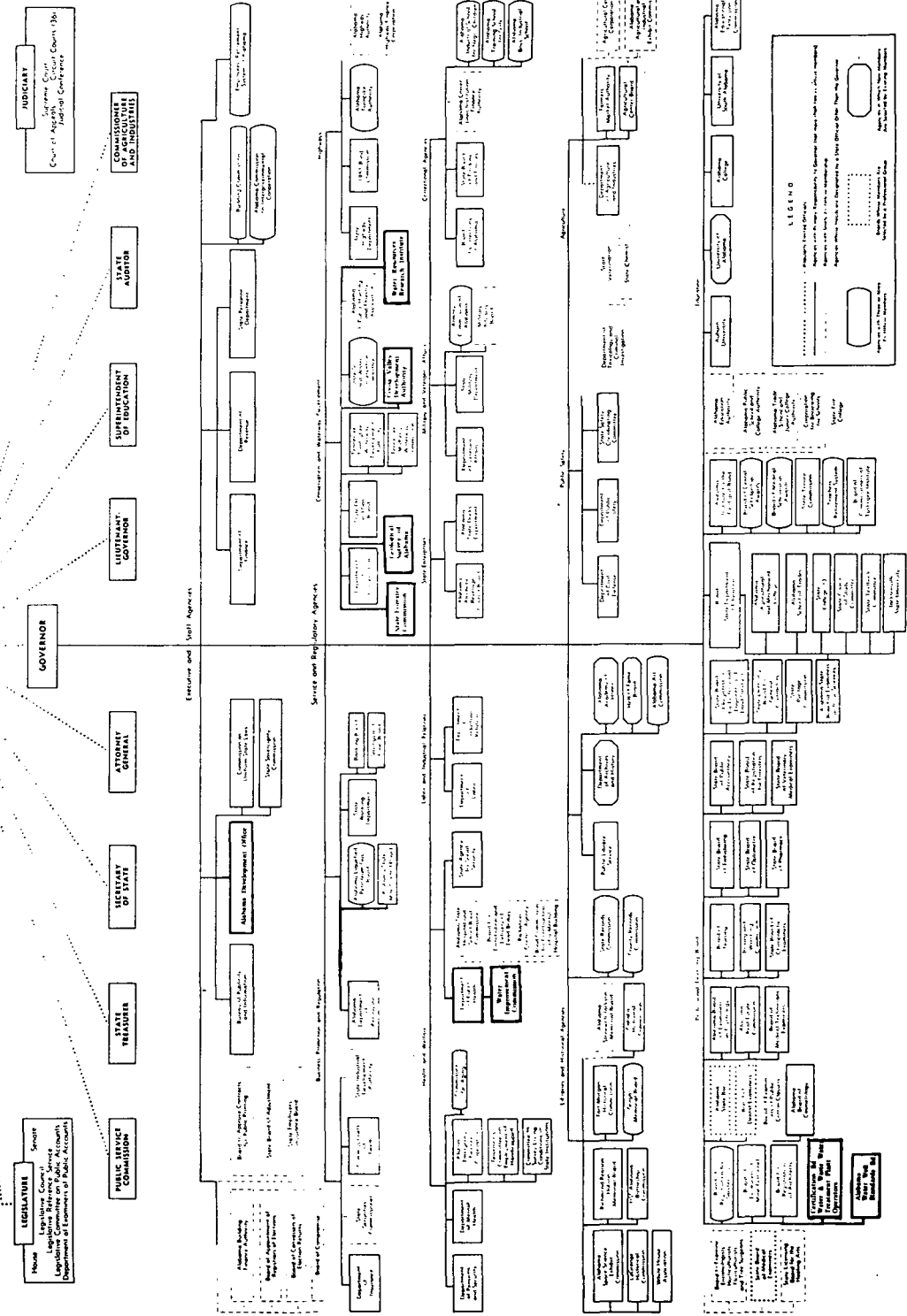
Other Federal Agencies too numerous to list here also should be included in the development of the proposed Model Center. It is hoped that this document will serve as an invitation to them to participate and help shape the ERISTAR concept.

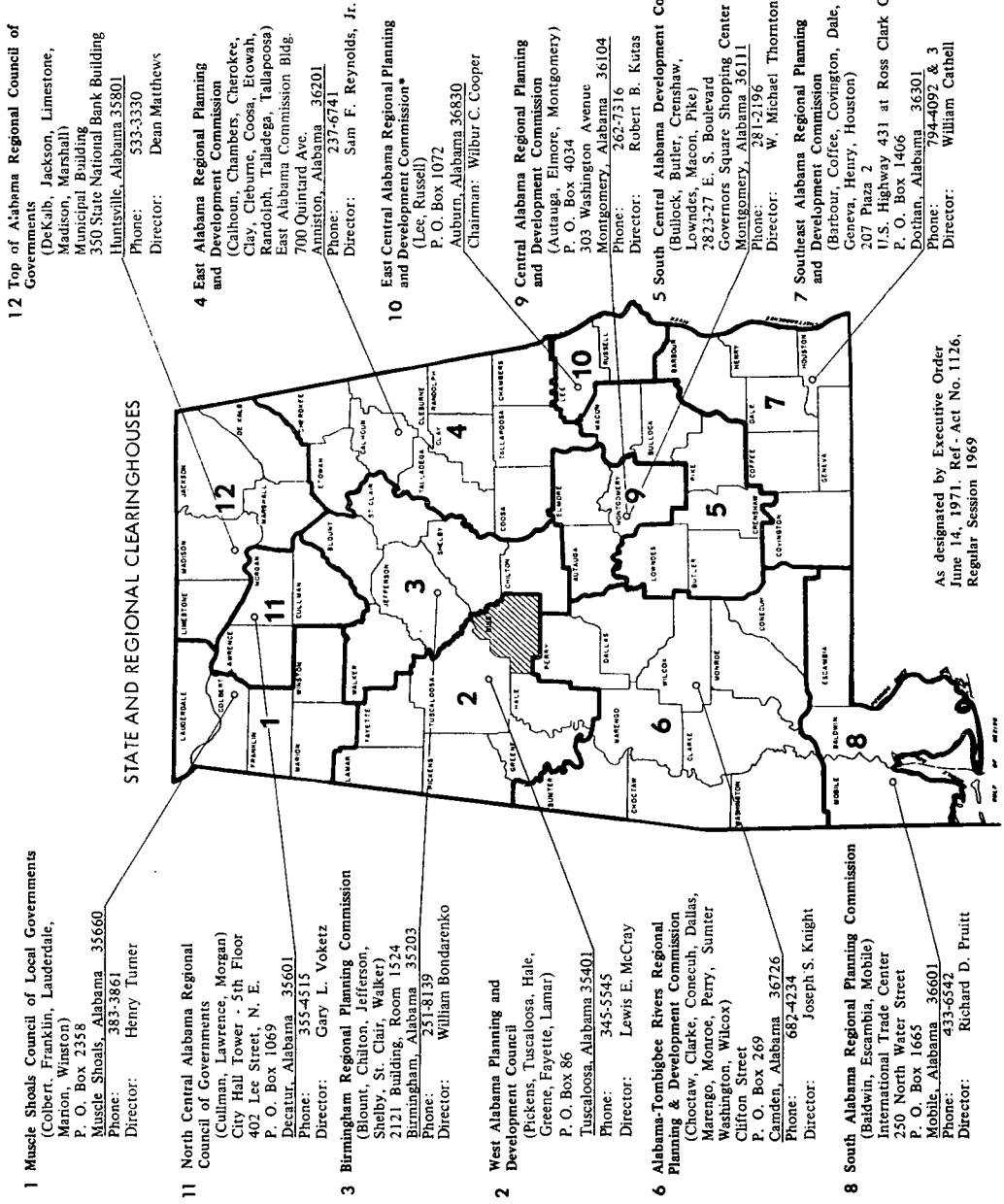
EXHIBIT 7-13: ALABAMA STATE GOVERNMENT

ALABAMA
VOTERS

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The Budget Prepared by
the Governor of Alabama
Series 1979





* Designated as Regional Clearinghouse but not staffed at time of printing.

Counties not members of Reg. Plng. & Dev. Commissions at time of printing.

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EXHIBIT 7-14: STATE OF ALABAMA COUNCILS OF REGIONAL GOVERNMENTS

7.3 ALABAMA, THE FIRST STATE CENTER

The State of Alabama was selected as the first state for instituting the ERISTAR concept development. The rationale for this selection is discussed in this section. The state government is depicted graphically in Exhibit 7-13 and described in the Alabama Government Manual [10].

7.3.1 Alabama Development Office (ADO)

The Alabama Development Office, one of the executive and staff agencies of the state government, is the agency that should be responsible for a State ERISTAR Center in Alabama. ADO is

"the principal staff agency of the Executive Branch to plan with the departments of state government and with other governmental units for the comprehensive development of the state's human, economic and physical resources. It also examines the programs administered by the State for their relevance to such plans [10]."

The ADO mission is consonant with the ERISTAR Center concept. Communications with ADO personnel indicate that there is receptivity to this idea and support.

7.3.2 Councils of Governments

The Alabama Councils of Governments (COGS), shown in Exhibit 7-14, have an active interest in the use of earth resources data and information. Some of these councils are currently interacting with the Marshall Center and ERISTAR planners. The COGS are ready made users of the ERISTAR System and are awaiting such a system.

7.3.3 Educational Institutions

The university, junior college, secondary and trade school systems in the state represent users of a state ERISTAR Network. Additionally they represent a resource to the ERISTAR State Center. One readily identifiable user and resource is the Co-operative Extension Service of the State Land Grant University. Marshall has had contact with this service and conducted joint experiments that indicate the contributions an earth resource information system can have for the agricultural community.

7.3.4 Alabama Earth Resources Data Committee

Executive order 43 of July 1972 has established an Alabama Earth Resources Data Committee. This committee is in effect a staff committee chaired by a member of the Alabama Development Office. The key text of this executive order is as follows:

The Committee shall:

- ° Work closely with the Marshall Space Flight Center in Huntsville, Alabama in compiling and studying earth observations from the Earth Resources Technology Satellite for the purpose of determining the feasibility of applying such data in the management of natural resources and the improvement of environmental quality in Alabama; and
- ° Compile information and reports and recommendations, and submit the same to the Governor: to disseminate such information to such other departments and agencies and users as the Governor may, from time to time, direct; and
- ° Coordinate with and utilize, with their consent, the services, personnel, and facilities of State or Federal agencies or private institutions in carrying out the duties and responsibilities of the Committee.

7.3.5 Alabama Geological Survey

As one of the principal generators and users of earth resource data and information, the Geological Survey of Alabama and the State Oil and Gas Board in the last decade have emerged as one of the most progressive and productive organizations of its type in the United States. Not only is the agency an experimenter in the NASA ERTS-A program, but it is nationally recognized as having transformed its research and publication products to the current needs of planners and decision makers on all levels of government. The Environmental Studies Atlas Series represents the combined geologic, engineering, sociologic, and political planning product unique to the Geological Survey.

Moreover, the Survey has long been at the forefront of computer utilization in pursuit of its scientific mission and in administration support. The Geological Survey is anxious to develop this aspect of its operations to provide a fully integrated information management system. Only sparsity of funding and priorities on the time of their limited staff have prevented this development to date.

7.3.6 Alabama ERTS Proposal

The University of Alabama, with the approval of the Governor and the concurrence of the appropriate state agencies, has made a proposal to NASA for a comprehensive application of ERTS data to the entire state of Alabama and NASA has approved the request. Preliminary efforts in regard to this activity have been extensive and have generated enthusiasm for an organization of earth resources data by the many agencies involved at both the State and Federal levels.

7.3.7 Marshall Space Flight Center Interest and Location

The Marshall Space Flight Center is located in the state of Alabama and has prior to the ERISTAR concept worked closely with state groups on earth resources problems and land use through the Environmental Applications Office. MSFC has shown an interest in information management prior to ERISTAR as it sponsored the UNISTAR study in 1970 [11] and is an active part of the University of Alabama ERTS proposal. It is felt that all these factors plus the location of the center would help to insure the smooth development of the first ERISTAR Center.

7.3.8 Geological Character

Alabama has a diverse physiographic character with five regions The Atlantic Gulf coastal plain, the Piedmont, the Appalachian Valley and Ridge, the Appalachian Plateau, and the Interior Low Plateau. These provide earth scientists with valuable material for study and analysis.

7.3.9 State Pollution Control Laws and Activities

The Alabama State Legislature has shown its concern for protecting the environment by enacting strong pollution control laws. The Chairman of the Subcommittee to the Legislative Council on Environmental Quality has expressed his views to the ERISTAR designers and indicated his receptivity to the ideas embodied in ERISTAR.

The state attorney general's office has moved without hesitation to stop operations defiling the environment. The State Supreme Court has affirmed a lower court ruling halting a strip mining operation in northern Alabama.

Alabama was the first state in which air pollution control laws were used to order industry to reduce operations to alleviate an air pollution crisis.

7.3.10 Environmental Conference

Alabama has conducted for the past two years (1970 and 1971) an Annual Environmental Conference at Auburn University. This conference has involved state and federal officials, industry and university personnel, as well as the public, in discussions on conserving and using earth resources. The conference has been cited by the President as an example for others to emulate.

The initiative of the state in this area of earth resources is demonstrated by this conference and is another factor in choosing Alabama.

7.3.11 Tennessee Valley Authority

The TYA operates in Northern Alabama and represents a user of the state ERISTAR Center as well as a contributor. The TYA has been involved in the development of earth resources since its inception. Representatives of TYA have conferred with the ERISTAR planners. The experience and presence of the TYA constitutes another plus for selecting Alabama as the first candidate for a State ERISTAR Center.

7.3.12 Marine Environmental Sciences Consortium

The Alabama Marine Environmental Sciences Consortium is a public, non-profit corporation dedicated to provide marine education, research, and service to the state of Alabama. The Consortium membership is made up of 17 public and private universities and colleges throughout the state under the coordination of Dr. C. Everett Brett, Director, University of Alabama Marine Science Institute. Through its Dauphin Island Sea Lab, the Consortium will coordinate research activities of the member institutions in the Mobile Bay and coastal zone, as well as offering instructional and research programs of its own. In its role as a coordinating body, the Consortium will be an excellent organization for collecting, analyzing and disseminating information on marine activities in the state of Alabama.

7.3.13 Water Resources Institute at Auburn University

The state has established a Water Resources Institute at Auburn University. The Institute stimulates plans and conducts original research of either a basic or practical nature in relation to water resources. This research may include, but is not limited to, the aspects of the hydrological cycle, the supply and demand for water, the conservation and best use of the available supply of water. The Institute is multidisciplinary in nature.

7.3.14 University of Alabama - Huntsville Center For Environmental Studies

The state has established a center to carry out environmental research and foster environmental education and public awareness. The center is located in Huntsville, Alabama, and is active in establishing liaison with state and federal agencies to carry out its mission for the citizens of Alabama.

7.3.15 Alabama Co-operative Extension

The Cooperative Extension Service is the oldest of the formally organized Extension Services at Auburn University. It was created by the Smith-Lever Act passed by the National Congress in 1914. Educational programs implemented by the Cooperative Extension Service are conducted in accordance with a Memorandum of Understanding between Auburn University and the United States Department of Agriculture.

Programs in each of the 67 Alabama counties are conducted under a Memorandum of Understanding between Auburn University and the county governing body.

Cooperative Extension Service programs are organized broadly around agriculture, marketing, home economics, youth activities, community improvement and resource development.

7.4 GEORGIA, SOUTH CAROLINA, TENNESSEE, MISSISSIPPI, KENTUCKY, NORTH CAROLINA, AND FLORIDA - CANDIDATES FOR SUBSEQUENT CENTERS

The salient points presented herein for the above mentioned states do not present the total picture but do show the potential for state ERISTAR Centers and identify activities indicative of groups that would work to develop state ERISTAR Centers.

7.4.1 Georgia

The state of Georgia is pursuing activities to coordinate state agencies' usage of earth resources information. ERISTAR planners met with representatives of Department of Trade and Industry, Department of Transportation Earth and Water, Department of Planning and Budget, Department of Natural Resources, Department of Administrative Services and Forestry Commission at the state capital. It was evident from the interest, enthusiasm and activities of the state planners that Georgia is a prime candidate for an ERISTAR Center. The Kennedy Space Center is currently planning some remote sensing overflights for the state and there is interest in an ERTS proposal. Mr. Paul Pritchard is the coordinator of joint efforts in earth resources and is receptive to the ERISTAR concept.

7.4.2 South Carolina

Mr. N. K. Olson of South Carolina is preparing a NASA ERTS-B proposal and has indicated his office is serving as a focal point for ERTS data in the state.

Clemson University has prepared a document entitled "A State of the Art Survey of the Applications of Aerial Remote Sensing to Coastal Engineering". This report plus other activities in the state indicate South Carolina is ready to cooperate in the development of a state ERISTAR Center.

7.4.3 Tennessee

Tennessee has a number of assets. Some of these are:

- ° Presence of TVA
- ° Presence of Oak Ridge National Laboratory and the Environmental Sciences Information Office
- ° University of Tennessee Space Institute which has held and planned several conferences on remote sensing as well as sponsoring a Remote Sensing Council for the Southeast Region of the United States. This Council met in June of 1972 and could be a positive force to promulgate the ERISTAR concept.
- ° The presence of a metro government in Nashville.

In addition, Senator Baker of Tennessee has sponsored Senate Bill 1113 to establish a structure that will provide integrated knowledge and understanding of the ecological, social and technological problems associated with air pollution, water pollution, solid waste pollution, general pollution and degradation of the environment, and other related problems. This bill indicates the interest of Tennessee and the nation in taking positive steps consistent with the ERISTAR concept.

Tennessee is currently attempting to enact state legislation that would place land use planning at the state level rather than the local level. The Tennessee State Planning Office is preparing an ERTS-B proposal.

7.4.4 Mississippi

Mississippi has demonstrated its interest and commitment to utilizing earth resources data. The state has a liaison office at the NASA MSFC Mississippi Test Facility (MTF). Mississippi State University is actively engaged in cooperative efforts at MTF and the state has a marine sciences program as well as being a participant in GURC.

7.4.5 Kentucky

The College of Agriculture, The University of Kentucky, held an Earth Resources Research Symposium in July 1972. Guest speakers from NASA and the faculty of University of Kentucky participated in the symposium conducted to acquaint representatives of state agencies and members of the faculty, University of Kentucky, with earth resources, including ERTS-S and multispectral analysis. An ERTS-A proposal is planned by the state.

7.4.6 North Carolina

North Carolina has a unique capability for housing an earth resources information center at its Research Triangle Park, located in the interior of the triangle formed by Duke University (Durham), University of North Carolina (Chapel Hill) and North Carolina State University (Raleigh). A number of environmentally-oriented agencies already have large research facilities in the Park, including the Environmental Protection Agency and the National Institute of Environmental Health.

Also located in Research Triangle Park are the Triangle Universities Computation Center (TUCC) and the N. C. Board of Science and Technology Information Center. TUCC is a large computing center serving the three universities, a number of industrial organizations, and smaller schools throughout the State by means of teleprocessing from remote terminals. The NCBS&T Information Center operates a large scale information retrieval system which has as its data base the multi-million document NASA and Department of Defense files as well as a variety of smaller document files. The Southern States Growth Board has just been located in the Triangle and could serve as a stimulus for the ERISTAR System.

This combination of environmental research and information processing capability adjacent to the state capital makes North Carolina's Research Triangle Park an obvious candidate for the location of both State and Regional earth resources information centers.

7.4.7 Florida

The information on Florida, as is the case with the other states, is not complete. The Kennedy Space Center is an asset to the state and represents an opportunity for federal support to a state ERISTAR Center and the ERISTAR System. Many environmental concerns have prompted action by the state government, indicating a receptiveness to a state ERISTAR Center.

7.5 SUMMARY

The Prototype ERISTAR Concept and its possible evolution in the Southeast has been described. The evolutionary plan called for a Model ERISTAR Center to be established at the Marshall Space Flight Center with this Model Center serving as a base for the development of operational ERISTAR Centers in Alabama and the other southeastern states. The Model Center would also serve in a regional role until the Regional Center is established in Atlanta. The Model Center would serve as a model for the entire ERISTAR System and would represent an on-going case study for innovation and demonstration. The Model Center is

seen to serve as a catalytic agent for the states and is in keeping with the tenor of the report by the Council of State Governments Report on Power to the States [10]. The exact structure of each state center would be commensurate with the needs of the state and the region as it is the purpose of the network to be an information system.

The Model Center would serve as a focal point for demonstrating the current activities of many government laboratories working in the area of earth resources. The Marshall Center, along with many of the government laboratories, would constitute a base of supporting technology facilities for the ERISTAR System.

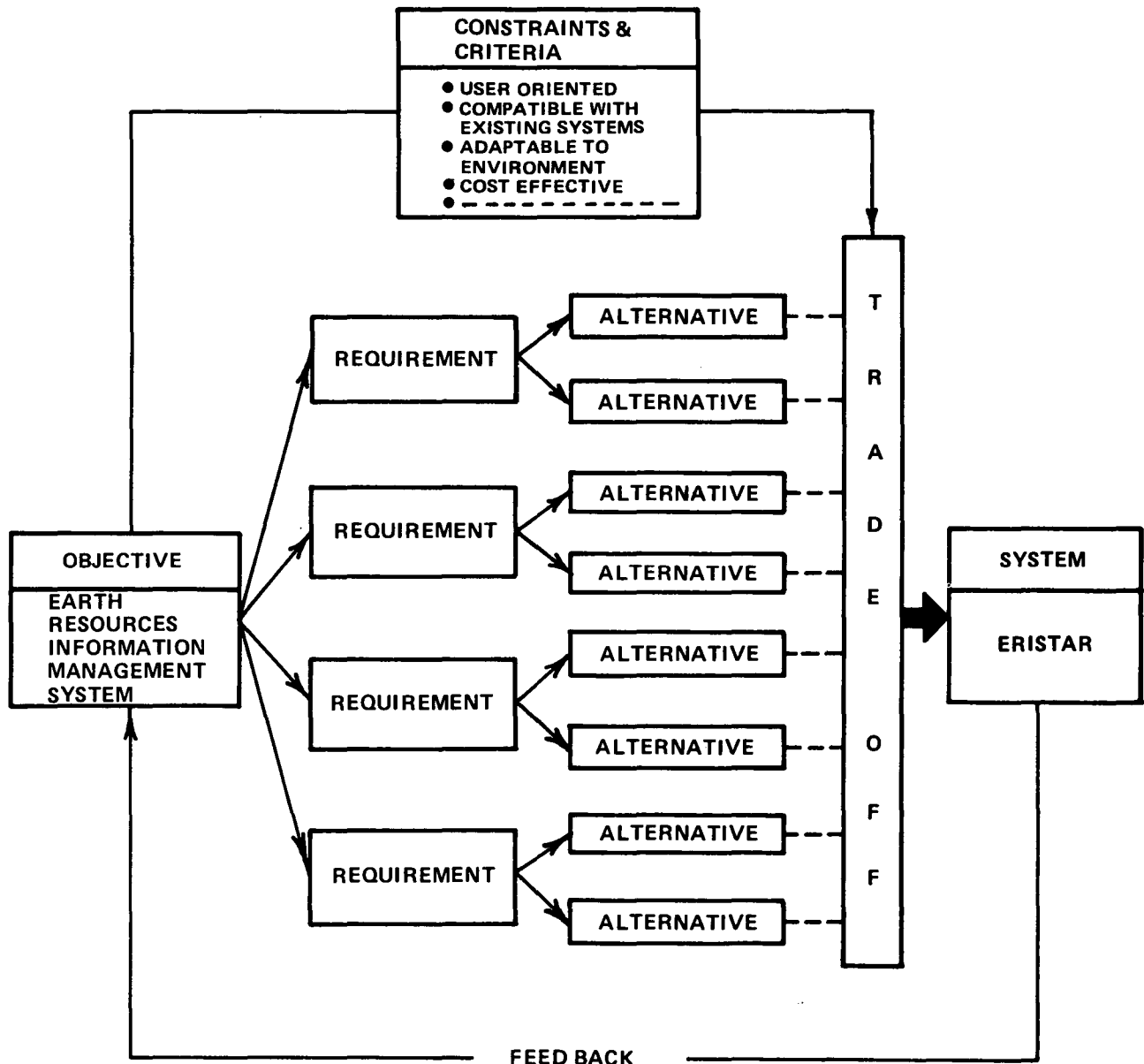
The prototype plan while not complete is the result of a system approach study that must undergo several cycles before it is complete. The prototype plan is part of an overall plan and represents a focusing of efforts by many in the area of earth resources. The continued application of the systems approach is recommended to gather detailed information on each of the states, sell the concept to a sponsor, and convert the concept to reality. The need exists, the states are ready, the technology is available, leadership is available; all that is lacking is an agreement by those concerned to begin.

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8. SUMMARY AND RECOMMENDATIONS



8.1 SUMMARY

The following remarks will focus on the importance and information related to earth resources, the need for ERISTAR and a brief review of ERISTAR.

8.1.1 Importance of Earth Resources

Man has an unlimited demand for earth resources. To satisfy these demands, man has acted as if these resources were virtually unlimited. This action has led to a severe mismanagement of earth resources, causing a number of critical socio-economic problems. Such problems include air and water pollution, improper land use and a shortage of specific minerals, to mention just a few.

Because of the seriousness of these problems, man now considers earth resources to be exhaustible. Hence, to survive man must properly manage these resources. Hopefully, man has acquired a new awareness of the importance of earth resources.

8.1.2 Information Related to Earth Resources

Information on earth resources has been acquired by observations at the ground level for a number of years. Information obtained at the ground level has been helpful in large measure in understanding earth resources. The method provides, however, only a limited coverage of these resources. The coverage of earth resources has been substantially increased in recent years by the use of remote sensing devices in aircraft at altitudes from 10 to over 60 thousand feet. Satellites presently obtain information on weather conditions. An experimental Earth Resources Technology Satellite (ERTS-A) was launched in July, 1972. Remote sensing devices aboard such spacecraft provide considerable additional coverage of, and acquire much more information on, earth resources. Using ground observations and remote sensing by aircraft and spacecraft, a number of federal and state agencies are obtaining voluminous amounts of information on earth resources. There is no appropriate method at the present time to handle this voluminous amount of information. In short, the flood of information on earth resources is inundating society.

8.1.3 Need for ERISTAR

To properly manage earth resources, man must possess extensive knowledge of these resources. It is difficult to obtain this knowledge because there is no appropriate method to handle the overwhelming volume of information obtained from the ground, aircraft and space. ERISTAR would allow for the storage, transformation, analysis and retrieval of earth resources information. By such proper handling of earth resources information, adequate knowledge can be obtained on these resources. Hence, with adequate knowledge, it would be

possible to properly manage earth resources. Proper management, in turn, would substantially reduce the number, or at least the seriousness, of socio-economic problems.

8.1.4 Review of ERISTAR

ERISTAR is a user-oriented system which will manage information related to earth resources. The system will have a National Center. It also will have Regional and State Centers. The Centers will be linked in a personal contact, mail, telephone and/or computer network. The National, Regional and State Centers can determine their own network structure to satisfy respective users.

A center at the National, Regional or State level is divided into three departments, namely, user services, information analysis and processing, and center and network operations. Briefly stated, the purpose of the departments is to obtain earth resources information from within ERISTAR or from other existing systems to rapidly answer the queries of the users.

A state is assumed to be responsible in large measure for the allocation of its resources. Hence, ERISTAR gives much consideration to the State Center. It can be easily implemented at the State level.

ERISTAR is designed to easily adapt to changes in users' queries, processing techniques and tools, sources of information, economic conditions, political structure and social patterns.

ERISTAR is international in scope, i.e., it could be copied by foreign countries throughout the world. Hence, ERISTAR in fact also could become an international network of centers handling voluminous amounts of earth resources information within and across national boundaries.

8.2 RECOMMENDATIONS

The following recommendations have been made.

- follow implementation plan for a model state ERISTAR center
- acknowledge the new technologies
- establish education in earth resource
- recognize roles of major organizations

8.2.1 Recommendation 1: Follow Implementation Plan for a Model ERISTAR Center.

A model state ERISTAR Center should be established under the direction of the Environment Applications Office, Science and Engineering, at the Marshall Space Flight Center, Huntsville, Alabama. Initially, the model center would function as an ERISTAR Center for the State of Alabama. Hence, all work should be coordinated with the Alabama Development Office.

The model center should use the technical expertise of other NASA centers. It also should consult with existing federal and state agencies. Moreover, the center should interface with existing information management systems which handle information related to the earth resources. In short, the development of the model center should be a united effort by all interested individuals, agencies and centers.

The model center would serve as a prototype for all states. It also would conduct the development work necessary to establish regional centers, as well as the national center.

The Environmental Applications Office, Marshall Space Flight Center would continue to operate the model ERISTAR Center for research purposes for the ERISTAR National, Regional and State System.

8.2.2 Recommendation 2. Acknowledge the New Technologies.

The new technologies associated with earth resources are remote sensing, exploding information processing requirements and man's use of information.

8.2.2.1 Remote Sensing

To obtain information on earth resources, rapid strides are being made at the present time in the development of remote sensors, including cameras (photographic, television and line scanning), radiometers, spectrometers, interferometers and radar systems. The optical and electronic instrumentation involved with these sensors, indeed, are new and complex.

The sensors produce a number of images. For example, a multiband image is produced when remote sensing is done simultaneously in each of several wavelengths. Interpretation of such images requires a skill which is difficult to acquire. More importantly, because of the voluminous number of images, it will be absolutely necessary to develop and understand machine image analysis.

8.2.2.2 Exploding Information Processing Requirements

The exploding demands for imagery processing can be compared with the computer technology and document technology as shown in Exhibit 3-7. Whereas the computer technology has been characterized by increasing the rate at which information is handled, the document technology has been

characterized by increasing the quantity of information that is stored and retrieved. However, the imagery technology simultaneously is increasing the rate and quantity of information to be handled. To meet this quantum jump in demand, advances in hardware development, software techniques and image processing need to be merged from the total systems viewpoint. To emphasize the urgency of this problem observe that only 5 percent of the ERTS-A data is being precision processed and automatic classification services are not provided. Yet users including some principle investigators, want the pictures analyzed and they do not have the personnel or equipment to do the job. If a concerted effort to solve this total problem is not started soon, numerous partial solutions can be expected to appear with the usual incompatibilities which result from divergent efforts. All ready, the storage problem is being approached with laser techniques and ultra high density tape (UHD) technology.

8.2.2.3 Man's Use of Information

The use of information is an accelerating technology. The implications of this technology have been examined in detail by the Conference Board. Important quotations from the Board are [1]:

"Information is a natural resource. Unlike other resources, it is heterogeneous and is not consumed in the process of use. It is a prerequisite to the organization and allocation of other resources"

A technology to harness the energy of this information will[1]:

"provide man with unprecedented capabilities to raise aspirations, multiply choices, alter values and develop a new knowledge base for human society"

Development of this new technology finds [1]:

"at stake the human individual - his rights, responsibilities, benefits and protection - how developing technology can be controlled and used constructively as a servant of man and not the master."

8.2.3 Recommendation 3. Establish Education in Earth Resources.

The public must be made aware of developments in earth resources. In addition, the new technologies dictate the establishment of an educational program.

8.2.3.1 Public Awareness

As the new information technology evolves, it will have significant educational implications. Two implications emphasized by the Conference Board are [1]:

"There is a shift in emphasis away from what is known, toward learning the means of finding out what one has to know when the need arises. This means learning to use the information process."

"The 'Have's' and the 'Have Not's' of knowledge may grow farther apart as information disparities grow. The powerlessness, alienation and political consequences that could develop must be avoided."

Reflecting on concerns such as these emphasizes the need for informing the public about the emerging structures and the educational requirements dealing with the new information technology.

The public must be made aware that proper design and use of information can be vital in handling societal problems such as those in the environmental area. Similarly, existing governmental agencies can perform their roles more efficiently.

Now more than ever before, the effects upon all individuals of the use of that information must be considered.

8.2.3.2 Curricula Development

New technologies, without a doubt, are involved in the field of earth resources. Many individuals must acquire knowledge of these new technologies through an educational program. The program should offer 3-week seminars to give an overall view of the technologies. The program also should offer short courses for a period of 3 months to allow individuals to obtain extensive knowledge. However, the educational program should offer degree programs at universities to allow individuals to acquire a professional knowledge of the new technologies.

The success of ERISTAR, and the proper management of earth resources, strongly depends on establishing such an educational program to disseminate knowledge of the new technologies. In other words, without an educational program, ERISTAR will not succeed and the proper management of earth resources will be impossible.

8.2.4 Recommendation 4. Recognize Roles of Major Organizations

The major organizations which play important roles in the ERISTAR system are NASA and NASA Centers, Federal Agencies, State Agencies, Universities, Professional Associations and Private Industry.

8.2.4.1 NASA and NASA Centers

NASA's experience in technological research and systems development can be of invaluable assistance during the implementation of ERISTAR. NASA could set up a working model center to illustrate the activities of a typical ERISTAR information center. State and federal governmental

representatives could be shown, thereby, the benefits which would accrue from an operational ERISTAR network. Once ERISTAR is operational, NASA could serve in an ongoing consultant capacity, focusing its research, development and technological expertise on user problems which need innovative techniques for solution. NASA could further educate ERISTAR staff and users alike, to put the results of NASA research into standard use.

8.2.4.2 Federal Agencies

Federal agencies are both potential users of ERISTAR and potential suppliers of information (sources) to ERISTAR. If this dual relationship is to be exploited to its fullest degree, the agencies must cooperate with ERISTAR in the building of effective and efficient interfaces. The interface might be facilitated by the establishment of a standardized information analysis center or office in each agency. The agencies should continue to develop new sources of information and be willing to seek new data in direct response to an ERISTAR request when appropriate and feasible. One of the federal agencies, new or existing, or an interagency council, should have ultimate authority over the operation of ERISTAR at the National and Regional levels.

8.2.4.3 State Agencies

The relationship of state agencies to the state level ERISTAR should be nearly identical to the relationship of the federal agencies to the federal level ERISTAR. They should develop standardized information analysis centers or offices through which they would interface with ERISTAR. They should supply ERISTAR with new data. One of the state agencies or an interagency council should have ultimate authority over the operation of ERISTAR at the state and sub-state levels.

8.2.4.4 Universities

University faculty will relate to ERISTAR both as users and information sources. University research capabilities could also be applied to the development of necessary technological support. The education function of universities and colleges could be utilized to prepare men and women to be effective and successful ERISTAR personnel and staff. Universities and colleges can also educate the student population in general about the value and use of ERISTAR. Finally, university and college professors can serve ERISTAR as subject area specialists, either on a part time basis or through special leaves financed by ERISTAR, a sabbatical, or both.

8.2.4.5 Professional Associations

Professional associations should play a two fold role in ERISTAR. First, they can serve in a special educational capacity to their membership, making the membership aware of ERISTAR, and where appropriate, helping their membership develop the skills necessary for ERISTAR employment. Second, the professional associations can aid in the establishment of performance standards for ERISTAR.

8.2.4.6 Private Industry

Industry and business have developed and are developing skills and technologies which will be of great value to ERISTAR. The ERISTAR management must work out appropriate mechanisms by means of which they can benefit from these skills and technologies without violating proprietary restrictions.

8.3 Final Remarks

Man now appears to understand that he depends on earth resources. Without these resources, man simply could not survive on the face of the earth. Consequently, it is essential that man acquires information on earth resources. Such information is absolutely necessary for the proper allocation of earth resources. Hopefully, this report will stimulate interest and cause action necessary to take a major step in acquiring and handling much needed information on earth resources.

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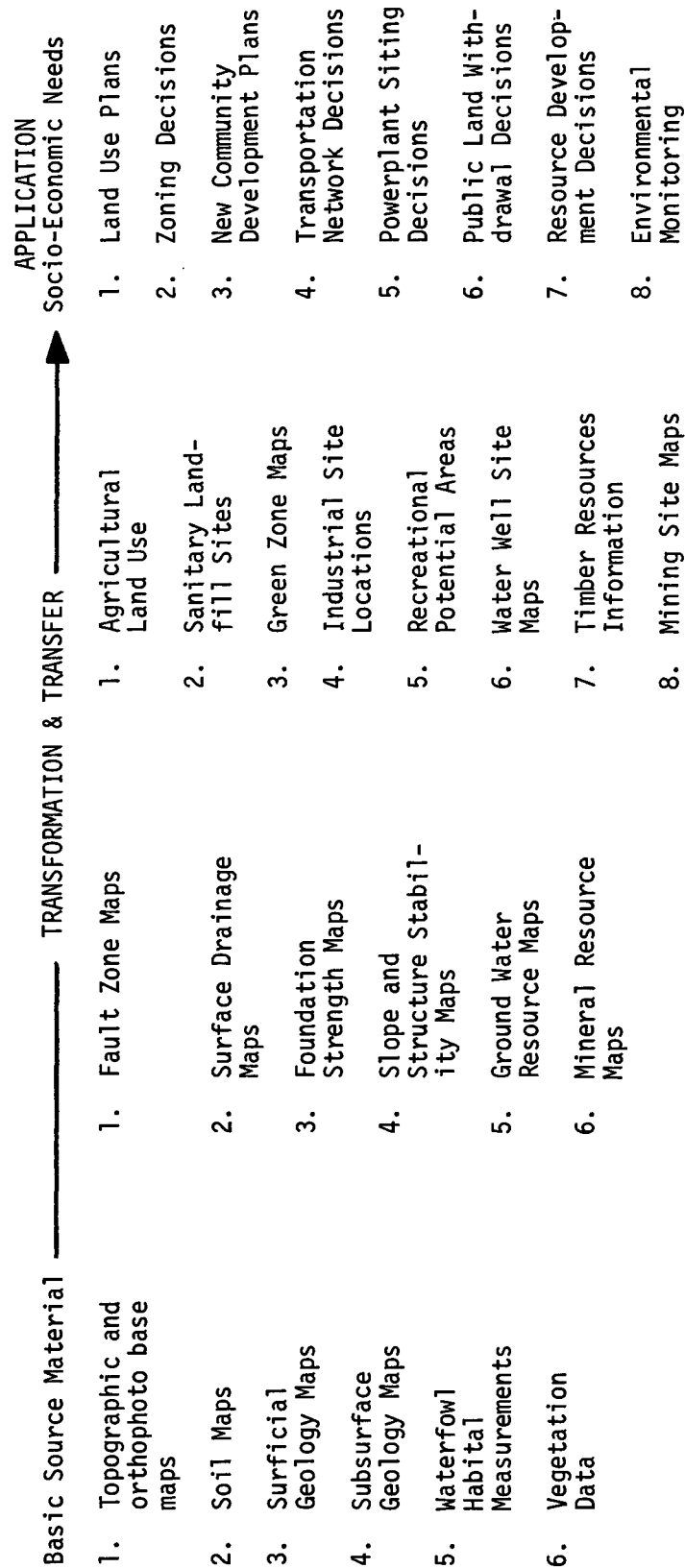
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APPENDICES

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APPENDIX A-1: EXAMPLES OF INFORMATION TRANSFORMATION, TRANSFER AND APPLICATION



Reference: Adapted from Figure 3 in Resource and Land Information (RALI): Program Description, U. S. Department of the Interior, June 29, 1972.

APPENDIX A-2: FEDERAL CHARTING AND MAPPING EFFORTS

Aerial photography:	Agricultural Stabilization and Conservation Service Coast and Geodetic Survey Geological Survey Soil Conservation Service Tennessee Valley Authority
Historical	National Archives and Records Service
Aeronautical charts and related publications	Coast and Geodetic Survey
Bathymetric maps	Coast and Geodetic Survey
Boundary information (inter- national):	
Maps of United States-Canada boundary	International Boundary Commission, United States and Canada
Maps of United States-Mexico boundary	International Boundary and Water Commission, United States and Mexico
Records of geodetic control surveys along international boundaries	International Boundary Commission, United States and Canada Coast and Geodetic Survey Geological Survey
Geodetic control data	Coast and Geodetic Survey U.S.Army Topographic Command Geological Survey Tennessee Valley Authority
Geologic maps	Geological Survey
Historical maps:	
Reproduction of maps on file	Library of Congress
Reproductions of military and other maps on file	National Archives and Records Service
Photostats of topographic quadrangles	Geological Survey
Hydrologic investigations atlases	Geological Survey
National Park topographic maps	Geological Survey

Nautical charts:	
U.S.coastal and territorial waters	Coast and Geodetic Survey
Charts and related publications, area outside the United States	Naval Oceanographic Office
Great Lakes and connecting waterways	Corps of Engineers,U.S.Army (Lake Survey)
Orthophoto maps	Geological Survey
Planimetric maps:	
Various scales	Geological Survey
Coastal areas of the United States	Coast and Geodetic Survey
National forest(small scale)	Forest Service
Relief maps, shades	Geological Survey
River navigation charts:	
Mississippi (lower)	Corps of Engineers,U.S.Army,Vicksburg
Mississippi (upper)	Corps of Engineers,U.S.Army,Chicago
Missouri	Corps of Engineers,U.S.Army,Omaha
Ohio	Corps of Engineers,U.S.Army,Cincinnati
Tennessee	Tennessee Valley Authority
River,reservoir,and damsite surveys (Western States)	Geological Survey
Shoreline surveys (coastal areas of the United States)	Coast and Geodetic Survey
Soil survey maps	Superintendent of Documents
Space photography	National Aeronautics and Space Administration Geological Survey
State maps:	
Base	Geological Survey
Federal lands administered by the Bureau of Land Management	Bureau of Land Management
Geologic	Geological Survey
Postal	Superintendent of Documents
Shaded-relief	Geological Survey
Topographic	Geological Survey
Tennessee Valley region maps (various subjects)	Tennessee Valley Authority

Topographic maps:

National Topographic Map Series
of the United States

Lower Mississippi River Valley

National forests (small scale)

Tennessee River Basin

Geological Survey

Corps of Engineers, U.S. Army, Vicksburg

Forest Service

Geological Survey

Tennessee Valley Authority

Township Plots:

Reproductions of original plats
on file except for the States
listed below

Reproductions of plats for Illi-
nois, Indiana, Iowa, Kansas,
Missouri and Ohio

Bureau of Land Management

National Archives and Records Service

REFERENCE: The National Atlas of the United States of America.
Washington, D. C.: U. S. Department of the Interior,
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APPENDIX A-3: RESULTS OF INTERVIEWS WITH THE GEOLOGICAL SURVEY OF ALABAMA

ORGANIZATION NAME: GEOLOGICAL SURVEY OF ALABAMA
STATE OIL AND GAS BOARD

ADDRESS: P. O. DRAWER 0
UNIVERSITY, ALABAMA 35486

TELEPHONE: 205/759-5721

HEAD: Philip E. LaMoreaux

PERSON (S) INTERVIEWED:

NAME	TITLE	ADDRESS	TELEPHONE
T. J. Joiner	Asst. State Geologist	Same	Same
W. E. Smith	Chief Geologist	Same	Same
J. A. Drahovzal	Geologist	Same	Same
D. B. Moore	Chief Geologist	Same	Same
P. H. Moser	Geologist	Same	Same
J. S. Tolson	Geologist	Same	Same
M. J. Dean	Publications manager	Same	Same
H. C. Barksdale	Water Resources Specialist	Same	Same

COOPERATIVE AGENCIES:

EPA	NASA (ERTS, thru Univ.)
Water Resources Research Institute	MSFC
EROS--Dept. Interior	TVA
Ala. Devel. Office	Ala. Cons. Dept.
U. S. Bureau Mines	Appal. Reg. Devel. Comm.
Water Well Driller Assoc.	U. S. Corps of Engineers
Ala. Water Improvement Commission	Ala. Power Co.
State Highway Dept.	International Hydrologic
Regional Planning Comm.	Decade
U. S. Forestry Service	
Private Org: U. S. Steel	
City of Huntsville	
Madison Co.	
Tuscaloosa Co.	

RELATED AGENCIES:

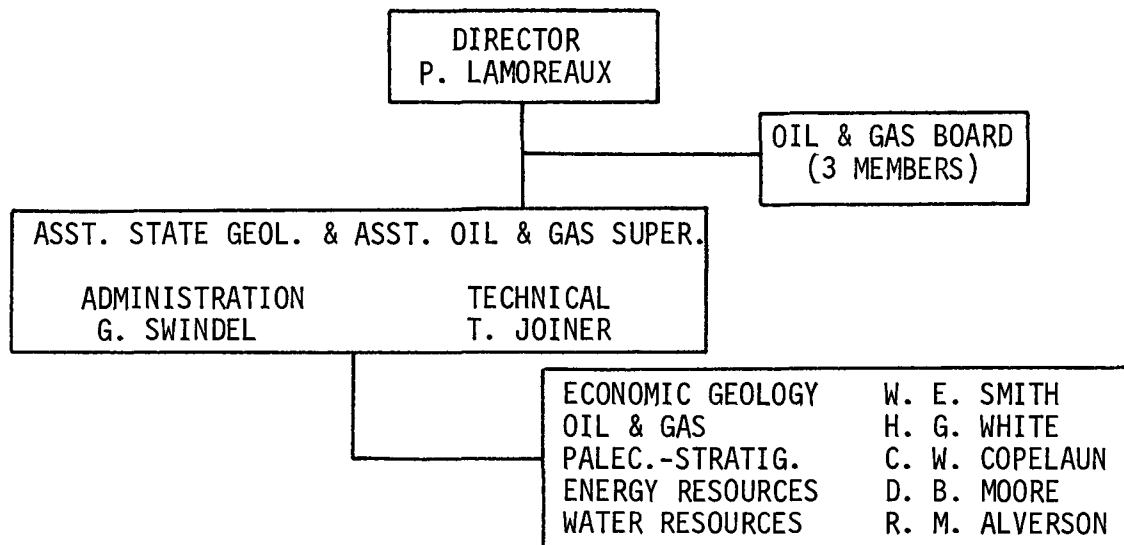
Principal Investigators
International Hydrologic Decade
Universities
U. S. Weather Bureau
Soil Conservation Service
EROS (Dept. Interior)

GEOPOLITICAL DOMAIN:

State of Alabama

ORGANIZATION:

ORGANIZATIONAL STRUCTURE (STAFF)



DESCRIPTION OF SYSTEM SERVICE

MISSION: To survey the geologic resources in the State of Alabama, and to prepare reports for the use of the citizens of the State.

SCOPE: Topographic mapping, geologic mapping, mineral resources, water resources, geophysical investigation, environmental studies, engineering geology, energy resources, oil and gas regulation.

METHODOLOGY: Research publication and advising.

DOCUMENTATION DESCRIBING SYSTEM OR SERVICE

NO _____

YES X

COPY: X

TITLE: Geologic Research: Key to Alabama's Future

AVAILABILITY: Upon request, Geol. Surv. Alabama

Address: As given on first page

INFORMATION SYSTEM (S)

NO _____

YES _____

TITLE: STORET

PUBLICATIONS

FLOW CHART

NO X

YES _____

TYPES

Library X

Data Bank X

Publications X

Serial X

Non-Serial _____

Services Inquiries & Pub. Talks, Reports

Network Particip. WHCS

Storet

Drilling report

Production report (Monthly)

Well Log description

INFORMATION MANAGER:

NO _____ YES X

NAME

TITLE

Publication Managers

Division Chiefs

Librarian

DESCRIPTION OF SYSTEM

GENERAL DATA CONTENT

Energy Resources

Petroleum

Hydrocarbons

Hydroelectric

Geophysics

Seismic

Gravity

Electrical

Magnetics

Economic Geology

Metallic

Non-Metallic

Paleontology

Stratigraphy

Geologic Maps

Structure

Mineral Deposits

Water Resources

Surface

Sub-surface

Geochemistry

Mineral

Water

Oil and Gas

Well Data

Production Data

Catalogs of Materials

Well Cores

Well Cuttings

E-logs

Descriptive Logs

Mineral Collection

Fossil Collection

Rock Collection

Publications

TRANSFORMATION PROCESS			DATA ACCESS METHOD	
FROM	TO			
	CONTENT	ATLAS FEATURE	PRESENTLY	RECOMMENDED
Topo. Maps	Geomorphology Physiography Mapping	Land Slope Map	Publications Map File	Indexed & Computerized Document System
Cross-Sections Profiles Geologic Column Geologic Map Structure Map	Geologic Structure Mapping Subsurface Data Stratigraphy	Geologic Structure Map	Field Reports Publications Well Logs Core Samples Well Cuttings Geophysical Logs Water File	Geologic

APPENDIX A-5: TABLES PREPARED FOR THE NATIONAL WATER DATA EXCHANGE STUDY

Table 1.—*Summary of water-data acquisition activities, based on catalog of information of water data, 1970 edition*

Agency	Surface water stations	Water quality stations	Ground water stations ¹	Areal invest. misc. activities
Department of Agriculture				
Forest Service.....	132	46	.....	76
Department of Commerce				
National Oceanic and Atmospheric Adm.				
National Marine Fisheries Service	18	65	.....	14
National Ocean Survey	87	.....	.....	2
National Weather Service.....	878	.....	.....	.....
Department of Defense				
Army				
Corps of Engineers	1,867	372	712	91
Navy				
Naval Facilities Engineering Command..	14	302	168	.....
Marine Corps	7	105	.....	.....
Department of Interior				
Bureau of Indian Affairs .....	.....	.....	143	4
Bureau of Land Management.....	45	.....	.....	2
Bureau of Reclamation	99	272	24,920	60
Bureau of Sport Fisheries and Wildlife .....	.....	33	.....	.....
Bureau of Mines .....	.....	.....	.....	20
Geological Survey.....	18,095	5,615	18,313	1,226
Independent Agencies				
Atomic Energy Commission.....	.....	614	362	.....
Environmental Protection Agency				
Water Programs Office .....	.....	3630	.....	114
International Boundary and Water Comm.	149	46	.....	.....
International Joint Commission.....	.....	.....	.....	1
Tennessee Valley Authority	133	141	172	61
Federal subtotal	21,524	8,241	24,790	1,671
Non-Federal	2,322	6,443	4,174	95
Total	23,846	14,684	28,964	1,766
Number of Federal agencies reporting	12	12	7	13
Number of non-Federal agencies reporting	71	159	9	34

¹Active observation wells reported in the 1968 edition of the catalog.

²Includes 3,087 observation wells that are represented in the catalog by 285 selected observation wells.

³Includes 98 stations reported by Public Health Service.

Table 2.—Summary of agency water data interests

Agency ¹	Surface water					Ground water					Surface-water quality					Ground-water quality							
	Discharge	Stage	Velocity	Basin parameters	Use	Physical	Geologic	Hydrologic	Use	Discharge	Laboratory analysis	Chemical	Biologic	Herbicides	Radio-chemical	Pesticides	Physical observations	Chemical	Biological	Herbicides	Radio-chemical	Pesticides	Physical observations
Agriculture	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X				
ARS	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X			
ERS	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X			
FS	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X	X
SCS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Commerce																							
Census																							
BDC					X																		
EDC-NODC																							
NOS		X															X						
NWS	X	X	X	X	X							X	X	X		X	X						
NMFS												X	X	X		X	X						
Defense																							
CE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X
NFEC																							
HEW																							
PHS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HUD																							
Interior																							
BPA	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BIA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BLM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BM	X			X	X	X	X		X	X		X	X	X		X	X	X	X			X	X
BOR	X	X		X	X				X	X		X	X	X		X	X	X	X			X	X
BR	X	X		X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X
SF&W												X	X	X		X	X						
NPS												X	X	X		X	X						
OSW																							
OWRR																							
GS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
State																							
DOT																							
FHWA	X	X	X	X	X	X			X			X					X	X					
CG																							
Ind.																							
Agencies																							
AEC																							
FPC	X	X		X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EPA-WPO	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
IJC																							
TVA	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X						
WRC	X	X	X	X	X	X	X	X	X	X			X				X						
Non-Fed. ²																							
Calif. ³	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X			X		X
N.Y. ⁴	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X			X		X
Penn. ⁵	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X

X: Specific interest in item based upon response to Data Handling Work Group questionnaire.

¹Member of Federal Advisory Committee on Water Data—questionnaire sent to each member.²Voluntary contribution from indicated agency.³California Department of Water Resources.⁴New York Department of Environmental Conservation.⁵Pennsylvania Department of Health.

Table 3.—Method of data communication from site to processing point

Federal agencies	Hand	Tele-commun.	Mail	Verbal (phone)	Other	Point of processing ¹					Remarks
						A	B	C	D	E	
Agriculture											
ARS	X		X			X			X	X	
ERS											
FS			X					X			
SCS											
Commerce											
Census											
BDC											
EDS-NODC	X		X			X				X	
NOS			X							X	
NWS		X	X	X	X		X			X	Other-radio.
NMFS	X								X		
Defense											
CE	X	X	X	X	X	X	X	X		X	Other-radio.
NFEC											
HEW											
PHS			X							X	
HUD											
Interior											
BPA											
BIA	X					X					Other agencies.
BLM											
BM											
BOR											
BR	X	X	X	X		X		X			
SF&W											
NPS											
OSW											
OWRR											
GS	X	X	X	X		X	X		X	X	
State											
DOT											
FHWA											
CG											
Ind. agencies											
AEC											
FPC											
EPA-WPO	X	X	X					X	X	X	
IJC											
TVA			X			X		X			Storet terminal.
WRC											
Non-Fed.											
Calif.	X	X	X	X		X	X			X	
N.Y.											
Penn.	X		X							X	Other agencies.

X: Indication of activity (based on response to Work Group questionnaire).

¹Point of processing: A, Field headquarters; B, District office; C, Regional office; D, Project office; E, Central headquarters.

Table 4.—Method of data communication from processing point to storage site

Federal agency	Hand	Mail	Computer	Tele-commun. w/computer	Storage location ¹						Remarks
					A	B	C	D	E	F	
Agriculture											
ARS	X		X		X				X		
ERS											
FS		X			X		X				
SCS											
Commerce											
Census											
BDC											
EDS-NODC	X	X							X		
NOS	X								X		
NWS		X							X		
NMFS	X	X			X				X		
Defense											
CE	X	X	X	X		X	X		X		
NFEC											
HEW											
PHS			X						X		
HUD											
Interior											
BPA											
BIA	X				X						
BLM											
BM											
BOR											
BR	X	X		X	X		X		X		
SF&W											
NPS											
OSW											
OWRR											
GS	X	X	X		X	X		X	X		
State											
DOT											
FHWA											
CG											
Ind. agencies											
AEC											
FPC											
EPA-WPO	X		X				X	X		X	Computer facility.
IJC											
TVA		X		X					X	X	Storet.
WRC											
Non-Fed.											
Calif.	X	X	X	X	X	X			X		
N.Y.											
Penn.	X	X							X		Other agencies.

X: Indication of activity (based on response to Work Group questionnaire).

¹Point of storage location: A, Field headquarters; B, District office; C, Regional office; D, Project office; E, Central headquarters; F, Laboratory.

Table 5.—*Method of data communication from collection site to storage site*

Federal agency	Hand	Tele-commun.	Mail	Verbal (phone)	Other	Storage location ¹					Remarks
						A	B	C	D	E	
Agriculture											
ARS	X		X			X		X		X	
ERS											
FS											
SCS											
Commerce											
Census											
BDC											
EDS-NODC	X		X							X	
NOS											
NWS			X	X	X		X			X	Other-radio.
NMFS	X		X							X	
Defense											
CE		X	X	X			X	X		X	
NFEC											
HEW											
PHS											
HUD											
Interior											
BPA											Other agencies.
BIA	X					X					
BLM											
BM											
BOR											
BR											
SF&W											
NPS											
OSW											
OWRR											
GS	X	X	X	X		X	X		X	X	
State											
DOT											
FHWA											
CG											
Ind. agencies											
AEC											
FPC											
EPA-WPO	X		X	X	X			X	X		Paper tape.
IJC											
TVA											
WRC											
Non-Fed.											
Calif.	X	X	X	X		X	X			X	Other agencies.
N.Y.											
Penn.	X	X	X							X	

X: Indication of activity (based on response to Work Group questionnaire).

¹Point of storage location: A, Field headquarters; B, District office; C, Regional office; D, Project office; E, Central headquarters.

Table 6.—Agency indication of techniques used for processing of water data

Federal agency	Computer	Manual	Techniques manuals available
Agriculture			
ARS	X	X	X
ERS			
FS	X	X	X
SCS	X	X	
Commerce			
Census			
BDC			
EDS-NODC	X	X	X
NOS	X	X	X
NWS	X	X	
NMFS			
Defense			
CE	X	X	X
NFEC			
HEW			
PHS	X	X	
HUD			
Interior			
BPA			Other agencies.
BIA			
BLM			Other agencies.
BM			
BOR			
BR	X	X	X
SF&W			
NPS			
OSW			
OWRR			
GS	X	X	X
State			
DOT			
FHWA			Other agencies.
CG			
Ind. agencies			
AEC			
FPC			
EPA-WPO	X	X	X
IJC			
TVA	X	X	
WRC			
Non-Fed.			
Calif.	X	X	X
N.Y.	X		
Penn.	X	X	Other agencies.

X: Indication of activity (based on response to Work Group questionnaire).

Table 7.—Agency indication of techniques used for retrieving water data

Federal agency	Machine storage	Tele-commun. w/computer	Manual files	Microform	Instructions for storage and retrieval ¹				Remarks
					SW	GW	QW	L&R	
Agriculture									
ARS	X		X		X	X			Instructions in preparation.
ERS									
FS	X	X	X	X					Instructions in preparation.
SCS			X						
Commerce									
Census									
BDC									
EDS-NODC	X			X	X		X		Uses guide.
NOS	X		X						
NWS	X		X	X					
NMFS			X						
Defense									
CE	X	X	X	X					
NFEC									
HEW									
PHS	X								
HUD									
Interior									
BPA									Other agency.
BIA			X						
BLM									Other agency.
BM									
BOR									
BR	X		X						Storet instructions.
SF&W									
NPS									
OSW									
OWRR									
GS	X	X	X	X	X	X	X		
State									
DOT									
FHWA			X						
CG									
Ind. agencies									
AEC									
FPC									
EPA-WPO	X	X	X	X			X		Storet manual.
IJC									
TVA	X		X						Retrieved from storet.
WRC									
Non-Fed.									
Calif.	X	X	X	X	X	X	X	X	Manual for machine storage.
N.Y.	X	X	X						
Penn.	X		X						

X: Indication of activity (based on response to Work Group questionnaire).

¹Instructions for storage and retrieval: SW, Surface water data; GW, Ground water data; QW, Water quality data; L&R, Lake and reservoir data.

Table 8.—Computer systems used for handling water data

Federal agency	Model	Operating system	Memory size	Storage devices	Output devices	Software
Agriculture						
ARS	IBM 360/30	OS	30K	Disc, tape, card.	Printer, tape.	Yes.
ERS						
FS	CDC 3100	MSOS 3	32K	Disc, tape.	Printer, tape.	Yes.
	U 1108	Exec. 2	64K	Disc, tape.	Printer, tape.	
SCS	IBM 369/65	OS	500K	Disc, tape, card.	Printer, card.	Yes.
	IBM 1130	Ver 2 OS	8K	Disc, tape, card.	Printer, card.	Yes.
Commerce						
Census						
BDC						
EDS-NCC	RCA 70/45	TDOS	131K	Disc, tape.	Printer, tape, card.	Yes.
NOS	IBM 360/30	DOS-100K	64K	Disc, tape.	Printer, tape.	
NWS	IBM 1620	OS	20K	Card.	Printer (off-line), card.	Yes.
	IBM 1130	OS	16K	Disc, card.	Printer, card.	Yes.
	IBM 360/50	OS		Disc.	Printer, tape, card.	Yes.
	CDC 3100	TOS	16K	Tape.	Printer, tape, card.	Yes.
NMFS	IBM 1130		8K	Disc.	Printer.	Yes.
Defense						
CE	RCA 301	TOS	40K	Tape.	Printer, tape, card.	No.
	GE 225	Br. II	8K	Tape.	Printer, card.	Yes.
	GE 427	DAPS	64K	Disc, tape.	Printer, card.	Yes.
	GE 115	DAPS	4K	Disc, tape.	Printer, tape, card.	Yes.
	GE 225	FIZMOP	16K	Tape, card.	Printer, tape, card, and plotter.	Yes.
	RCA		40K	Tape, card.	Printer, tape, card.	
	GE 225	Fort IV	16K	Tape, card.	Printer, tape, card, plotter.	Yes.
	IBM 360/30	TOS	32K	Tape.	Printer, card.	Yes.
	IBM 1130		8K	Disc.	Printer, card.	Yes.
	GE 225		8K	Tape.	Printer, card.	Yes.
	GE 427	OS	32K		Printer.	Yes.
	GE 425	TOS	64K	Disc.	Tape, card.	
	GE 225	TOS	8K	Tape, card.	Printer, tape, card.	Yes.
	GE 225	OS,TOS,DOS	8K	Tape.	Printer, card.	Yes.
	CDC 6400		65K	Disc, tape.	Printer, plotter.	Yes.
	IBM 7094	TOS				
	CDC 6600	TOS				
	IBM 360/50	OS	150K	Disc, tape.		
	IBM 360/50	OS	150K	Disc, tape.	Printer, card.	Yes.
	IBM 360/50	OS	512K	Disc, tape.	Printer, card, teletype.	Yes.
	IBM 1130	DOS	16K	Disc.	Printer, card, teletype.	Yes.
	U 1108		256K	Drum, tape.	Printer.	Yes.
	GE 225	TOS	16K	Tape, card.	Printer, plotter.	Yes.
	GE 220		16K	Tape, card.	Printer, tape, card.	Yes.
NFEC						
HEW						
PHS	H400	TOS	8K	Tape.	Printer, tape, card.	Yes.

Table 8.—Computer systems used for handling water data—Continued

Federal agency	Model	Operating system	Memory size	Storage devices	Output devices	Software
HUD	CDC 6400	Scope 3.2	131K	Disc.	Printout.	Yes.
Interior						
BPA						
BIA						
BLM						
BM	H 800/200	H	32K	Tape.	Printer, card.	Yes.
BOR						
BR						
	IBM 1620	Monitor 1	40K	Disc.	Printer, card, plotter.	Yes.
	U 11008	Ex 8	132K	Drum.	Tape, plotter.	Yes.
SF&W	IBM 360	OS	1000K	Disc, tape, card.	Printer, tape, card, plotter.	Yes.
OSW						
OWRR						
GS						
State	IBM 360	OS	1000K	Disc, tape, card.	Printer, tape, card, plotter.	Yes.
DOT						
FHWA						
CG						
Ind. agencies	IBM 360	OS 18.6 MVT	1000K	Disc, tape.	Printer, tape, card, plotter, terminal.	Yes.
AEC						
FPC						
EPA-WPO						
IJC	IBM 360/50	OS	512K	Disc, tape.	Printer, tape, disc.	Yes.
TVA						
WRC						
Non-Fed.	CDC 3300		96K	Tape.	Printer, tape, plotter.	Yes.
Calif.						
N.Y.						
Penn.	IBM 360/50					

Table 9.—Media for release of water data

Federal agency	Publication	Printout	Hand tabulation	Microform	Verbal (phone)	Other
Agriculture						
ARS	X					Special request.
ERS	X					
FS	X	X	X	X	X	Pub. of other agencies.
SCS						
Commerce						
Census						
BDC						
EDS-NODC	X	X	X	X	X	Radio & reports to OFA included.
NOS	X					Radio, teletype.
NWS	X	X	X	X	X	Radio reports.
Defense						
CE	X	X	X		X	
NFEC						
HEW						
PHS	X	X				
HUD						
Interior						
BPA						Data used for operation only.
BIA			X			
BLM						
BM						
BOR						
BR	X	X	X		X	
SF&W						
NPS						
OSW						
OWRR						
GS	X	X	X	X	X	
State						
DOT						
FHWA						
CG						
Ind. agencies						
AEC						
WPC						
EPA-WPO	X	X	X	X	X	Radio & reports of OFA included.
TVA	X	X	X		X	
WRC						
Non-Fed.						
Calif.	X	X	X	X	X	
N.Y.	X	X	X			
Penn.	X					

X: Indication of activity (based on response to Work Group questionnaire).

AGENCY ABBREVIATIONS

AEC.....	Atomic Energy Commission
Agriculture.....	Department of Agriculture
ARS.....	Agricultural Research Service
BDC.....	Bureau of Domestic Commerce
BIA.....	Bureau of Indian Affairs
BLM.....	Bureau of Land Management
BM.....	Bureau of Mines
BOR.....	Bureau of Outdoor Recreation
BPA.....	Bonneville Power Administration
BR.....	Bureau of Reclamation
Calif.....	California Department of Water Resources
CE.....	Corps of Engineers
Census.....	Bureau of the Census
CG.....	Coast Guard
Commerce.....	Department of Commerce
Defense.....	Department of Defense
DOT.....	Department of Transportation
EDS.....	Environmental Data Service
EPA.....	Environmental Protection Agency
ERS.....	Economic Research Service
FHWA.....	Federal Highway Administration
FPC.....	Federal Power Commission
FS.....	Forest Service
GS.....	Geological Survey
HEW.....	Department of Health, Education and Welfare
HUD.....	Department of Housing and Urban Development
IJC.....	International Joint Commission
Ind. Agencies.....	Independent Agencies
Interior.....	Department of the Interior
NCC.....	National Climatic Center
NFEC.....	Naval Facilities Engineering Command
NMFS.....	National Marine Fisheries Service
NOAA.....	National Oceanographic and Atmospheric Adm.
NODC.....	National Oceanographic Data Center
Non-Federal.....	Non-Federal Agencies
NOS.....	National Ocean Survey
NPS.....	National Park Service
NWS.....	National Weather Service
N.Y.....	New York Department of Environmental Conservation
OSW.....	Office of Saline Water
OWRR.....	Office of Water Resources Research
Penn.....	Pennsylvania Department of Health
PHS.....	Public Health Service
SCS.....	Soil Conservation Service
SF&W.....	Bureau of Sport Fisheries and Wildlife
State.....	Department of State
TVA.....	Tennessee Valley Authority
WPO.....	Water Programs Office
WRC.....	Water Resources Council

APPENDIX B

DETAILED ANALYSIS

The analysis phase of the systems approach entails, in addition to the definition of requirements and delineation of alternative approaches, a detailed examination of selected elements of the problem. This section discusses several such areas of detailed analysis. Analyses are given for the topics of data base systems, microform techniques and products, resolution, spectrum analysis, pattern recognition, the Laboratory for Applications of Remote Sensing (LARS), information versus data, investment and operating costs, and the NASA Data Processing Facility. These descriptions capsule the present status of these areas, and provide a background from which to consider alternative approaches.

B-1 DATA BASE SYSTEMS

In order to provide a fast response to answer user requests and to cope with the vast volumes of data to be managed, a data base management system should be included in the design. Although specialized systems can be tuned to show high performance on particular tasks, they are less flexible and less transferable than generalized data base management systems. The high unpredictability of future requirements in the developing area of earth resources should constrain the design to consider only generalized systems. The functions which such a software package should include are definition, creation, maintenance, and interrogation of a data base. Of the many such systems which have been implemented or are under development, only three are available on Univac 1108 computer equipment and sufficiently documented to be considered at this time [21, 22, 23]*. The particular characteristics needed for the earth resources information management system include:

- o Easy utilization in a number of different disciplines
- o Flexibility in handling diverse data base relationships
- o Data integrity and access control
- o Minimization of effort required to transfer to new hardware configurations
- o Modest memory and hardware requirements
- o Extendable to very large data bases
- o Minimum operation system interface requirements.

*These citations refer to the items listed in the References section of Chapter 3.

B-2 MICROFORM ANALYSIS IMPLICATIONS

The need for reduction in physical size of documents for storage purposes has fostered the development of a wide range of equipment [24, 25]. The term microform includes all forms which record microimages. A microimage is defined as a picture of text or similar material which is too small to be read without magnification. Microfilm is a fine-grain, high resolution film containing a greatly reduced image. Microfiche is a sheet of microfilm containing multiple microimages in a grid pattern. Normally either 16 millimeter (mm) or 35 mm widths are used for microfilm. Some cassettes have 100 foot rolls. Exhibit B-1 tabulates the number of images which could be stored per cartridge depending on the resolution assumed. Exhibit B-2 tabulates the number of images which could be stored per fiche depending on the resolution.

Since much of the existing earth resources information is on hard copy, a systematic method of reducing the relevant portions for dissemination needs to be developed. The rationale for selecting microfiche to solve a similar problem with the Federal Catalog System (FCS) is well documented [9]. Also due to the potential for vast volumes of computer output, the capability of computer-output-microfilm (COM) should be interfaced with microfiche storage plans.

Since much of the analysis of earth resources data will result in contour diagrams, classification drawings, maps and similar pictorial forms, the capability needs to be included in microform handling for document images such as aperture card facilities. An aperture card has the advantage over microfiche for internal transmission in that it can be computer processed to a limited extent to assist in sorting and filing. The Document Storage and Retrieval System (DARE) [26] of the U. S. Army Missile Command (MICOM) is used for the active blue print file. Its production capability can exceed 6000 cards per day plus 2000 updates to a file of over 800,000 images. The operational cost to duplicate cards in such quantities is about 3 cents each. However, current aperture card equipment is oriented toward 35 mm film instead of 70 mm film. Thus, some hardware development would be required before a fully automated system could be delivered for earth resources. For comparison, the 40,000 frame per month capability of the NASA Data Processing Facility is within the aperture card rate realized at MICOM.

B-3 RESOLUTION

Resolution, and here we mean spatial resolution, is the level of detail that a viewer can discern from an image or display. For example, in the pictures of the planet Earth taken by the astronauts from the Apollo spacecraft we can note the continents but cannot detect such details as roads or cities. Resolving power [27] is then the reciprocal of the smallest observable separation of adjacent lines in a test pattern.

Reduction	No. Images on 16 mm Film	No. Images on 35 mm Film
24:1	2,400 (1 track)	4,800 (2 tracks)
42:1	4,200 (1 track)	16,800 (4 tracks)
48:1	9,600 (2 tracks)	19,200 (4 tracks)
50:1	10,000 (2 tracks)	20,000 (4 tracks)

EXHIBIT B-1: ROLL/CARTRIDGE COMPACTION POTENTIAL

Reduction Ratio	Letter-Size Pages 10 ¹ / ₂ "x8"		Computer Printout 11"x14"	
	No. Rows & Col.	No. Images	No. Rows & Col.	No. Images
20:1	5x12	60(COSATI)	5x7	35
24:1	7x14	98(NMA)	7x9	63
30:1	9x18	162	8x11	88
32:1	9x20	180	9x12	108
36:1	10x20	200	10x14	140
42:1	12x24	288	12x16	192
48:1	14x28	392	13x18	234
60:1	18x36	648	17x22	374
72:1	21x42	882	20x27	540
84:1	25x50	1,250	24x32	768
96:1	28x56	1,568	27x36	972
100:1	30x60	1,800	28x38	1,064
108:1	32x64	2,048	31x41	1,271
120:1	36x72	2,592	34x45	1,530
150:1	45x90	4,050	43x57	2,451
180:1	54x108	5,832	51x68	3,468
210:1	63x126	7,938	60x80	4,800

EXHIBIT B-2: FICHE COMPACTION POTENTIAL

The measurement of resolution is usually in terms of the number of line pairs per millimeter that can be distinguished in an image. Line pairs are chosen as a standard target to be viewed; the target having a series of pairs of black lines, with each line in the pair and the white separation being of equal length and width. Each pair in the series gets smaller and smaller until the viewer finds he can see only a blob rather than a pair of black lines. The size of the limiting pair is the resolution of the image.

This is quite analogous to the technology of a television screen. Consider the screen as a series of small dots in a rectangular grid or matrix, where each dot can project one of several levels of grey, or even one of several colors if we have a color set. The level of detail, or resolution, is dependent on the fineness of the grid.

Resolution can be translated from a measure of image detail to a measure of what size of objects can be discerned in the image. This ground resolution is equal to the product of the scale factor times the reciprocal of the image resolution. The scale factor is equal to the ratio of the distance of the camera from the object being viewed (altitude) to the distance between the lens and the image plate or film (focal length). This is also equal to the ratio of the diameter of the image plate. For example, a camera in a satellite at an altitude of 500,000 feet with a focal length of one foot yields a scale factor of 500,000. If the resolution of the system output is 100 line pairs per millimeter, the ground resolution is 5000 millimeters, or about 17 feet. Thus, the camera can detect details such as a road if it is wider than 17 feet.

It must be noted that occasionally some detail can be seen of objects smaller than the limiting resolution, due to sharp contrast and perhaps prior knowledge of the area under consideration. The resolution limit is thus an average limit, not an absolute one. And while we may note the existence of a narrow road, we cannot be sure if it is one road or several very narrow, parallel paths.

Resolution limits are a function of several variables. Some of these are altitude, ground coverage, focal length, film granularity, dimension of the image plate, intensity and contrast of the target, film format, orbit inclination for satellites, lens f-ratio, field of view, film sensitivity, lens aperture, light wavelength and the human element, both in terms of visual capacity and subjective processing ability [27, 28]. Thus we see that determining the resolution is a very complex process.

The degree of resolution needed depends on the use and depth of analysis of the images. For example, land use studies, snow surveys, tectonic studies, glacier location, and tree counts require a ground resolution of less than 20 meters, according to experts [29, 30]. Farm planning, thematic mapping, geomorphic studies, and wave refraction studies require a ground resolution of 20-100 meters. Sea water color

analysis, cloud studies, and grass crop inventories need only a ground resolution of 300 meters. Thus, the resolution needs to be increased only as the need for detail increases.

However, for a constant ground coverage, as resolution increases so does the amount of information that must be transmitted, collected, and analyzed. A television screen with a 500 x 500 grid and 8 grey levels yields 750,000 bits of information every time a picture is taken. The new Earth Resources Technological Satellite (ERTS) will send 15 million bits of information to earth every second. The rate of information flow may increase to 50 million bits per second when the plans for a space station [10] are implemented. Thus, the utility of the user for higher resolution may not always be increasing at a rapid rate. In fact, it may even level off or decrease, due to the enormous information handling problems.

The limits on the resolution capability are imposed by the technology of the visual system, cost, security, and weight. On the Earth Resources Technology Satellite (ERTS) recently put into orbit, sensors on board are yielding a ground resolution of around 500 feet on the average [18]. Better sensors might perhaps be developed, but there are cost considerations that must be taken into account. Moreover, there is the weight factor, especially for airplanes and satellites, where a big problem is the poundage of film or magnetic tape needed to record the images. It would take fourteen pounds of film to provide images, at a scale of 800,000:1, of the United States. In addition, military and political restrictions may prohibit the sensing of data so detailed as to include classified information such as missile sites. Finally, it is noteworthy to point out that most processing techniques reduce resolution by about 10% per generation.

The conclusion is that resolution is a complex variable that must be taken into consideration in the design of any earth resources information system.

B-4 SPECTRUM ANALYSIS IMPLICATIONS

The spectral range of earth resource information is shown in Exhibit B-3 [41]. The sensors used for ERTS and SKYLAB are located on the electromagnetic spectrum in Exhibit B-4 [21]. The detailed portion near the visible spectrum is expanded in Exhibit B-4. The first observation is that those areas of the spectrum where the solar transmission is high are well covered. However, many of the features of interest lie outside these ranges as shown in Exhibit B-3. Hence, in the future more experiments in other bands as well as greater refinement within bands expect to further increase the amount of information to manage and the diversity of form in which it is collected.

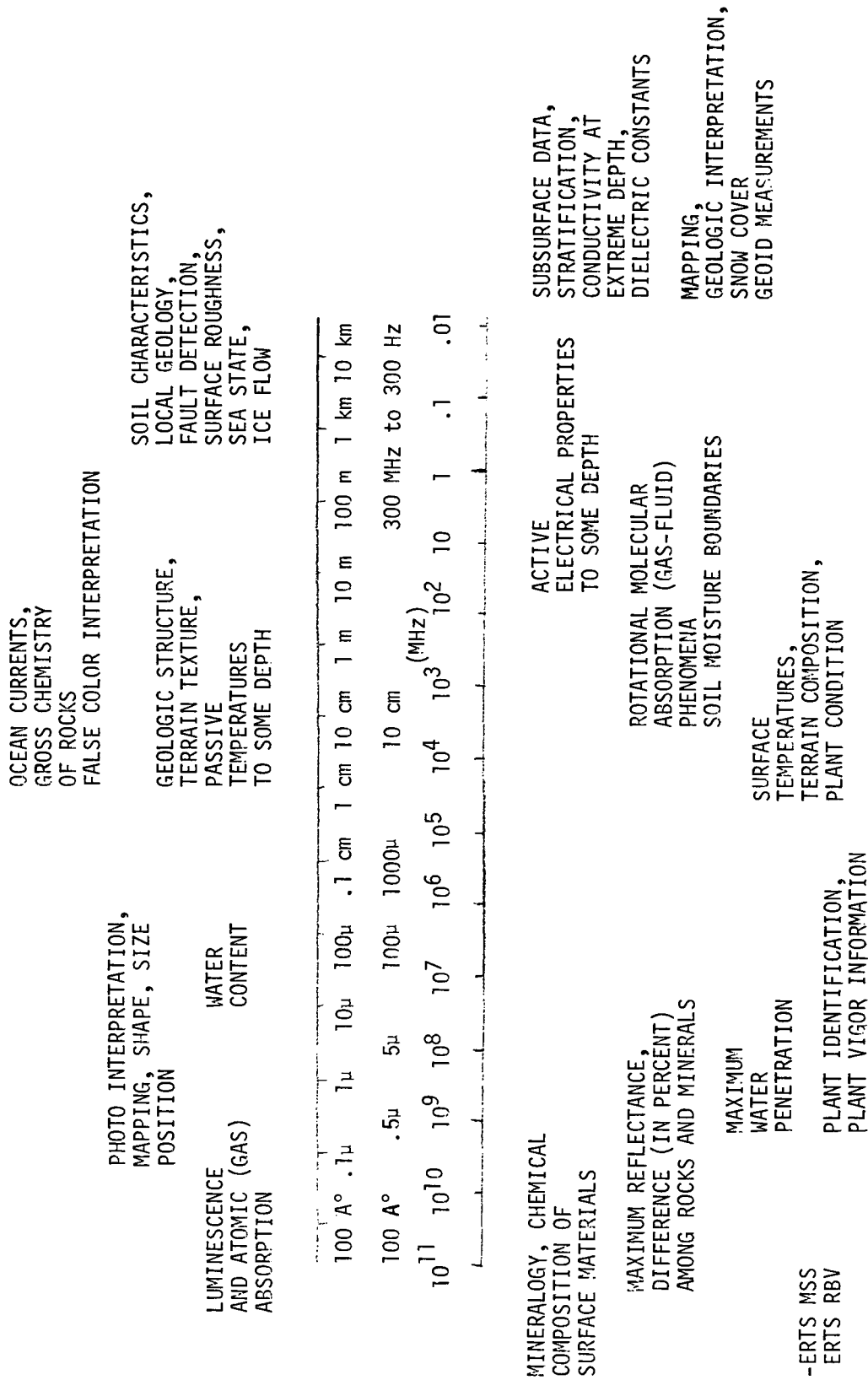


EXHIBIT B-3: THE SPECTRAL RANGES OF EARTH RESOURCES SENSORS

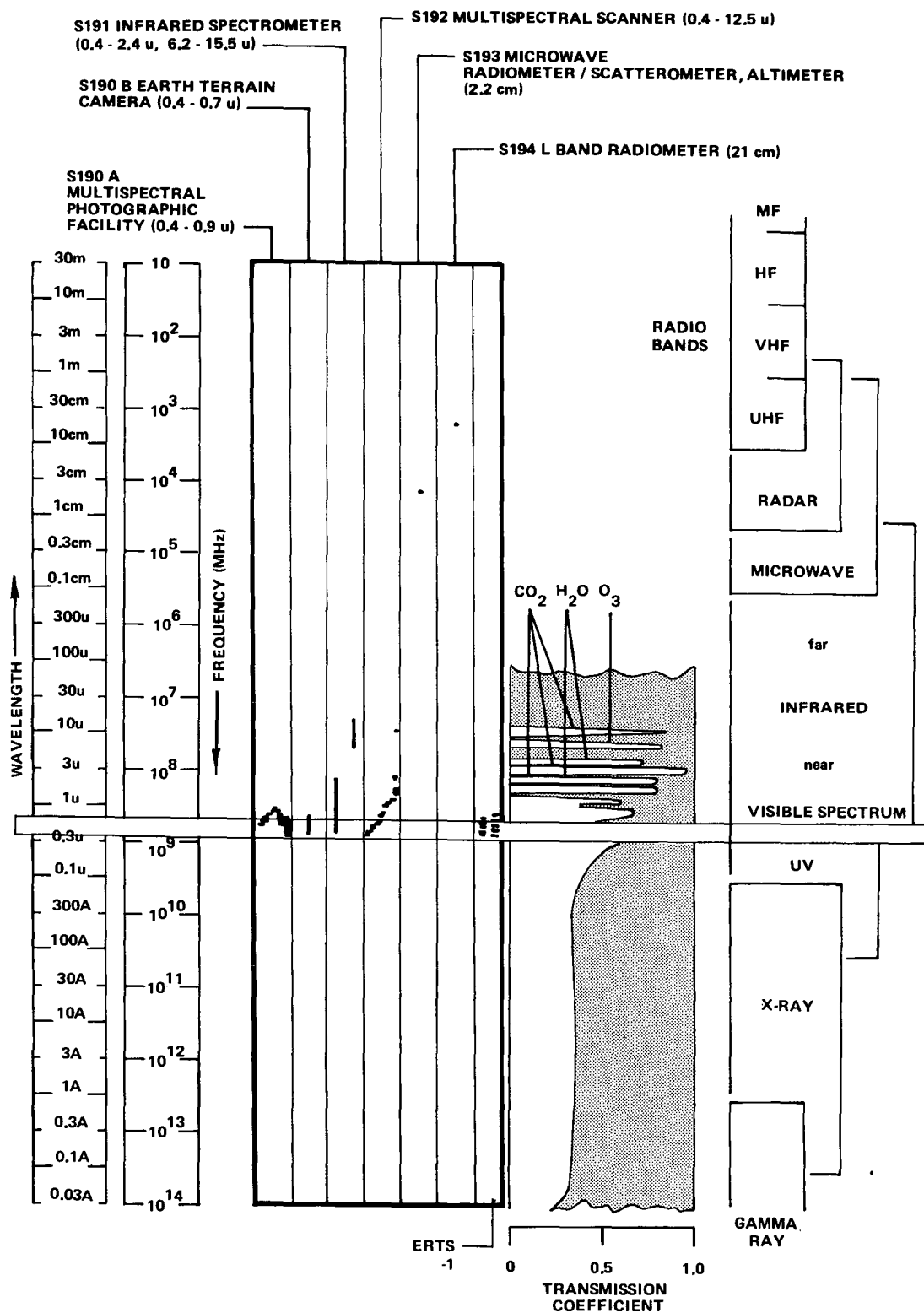


EXHIBIT B-5: SPECTRAL COVERAGE WITH RADIATION

B-5 PATTERN RECOGNITION

One of the most important aspects of a successful system plan to manage earth resources is to incorporate into the system the capability of automatic information processing. This need can be filled by the application of pattern recognition concepts which deal with the use of machines to perform automatic data classification.

The most salient application, with respect to earth resources, of pattern recognition techniques is perhaps the well-known set of classification algorithms utilized by Purdue's LARSYS system [32]. This system is discussed in detail in Appendix B-6 below.

Another important immediate application of pattern recognition is to the generation of land use maps on an international scale. As of this writing, the ERTS/A satellite is transmitting thousands of images for every 18 day cycle [5]. Rates of approximately 10^{12} bits of information per month are already a part of this information gathering system. Obviously if proper use is to be made of this information, there must be a provision to automatically classify at least parts of these data.

The sophistication required to generate land use maps by machine depends on the application. For example, the requirements to generate a land use map for the Amazon basin are considerably less demanding than those required to generate a similar map for the city of New York.

Pattern recognition technology has been developed to the point where it can be applied to straight-forward problems such as crop classification from aircraft infrared imagery [32]. It is not expected that similar classifications will be performed on satellite images until the resolution of these images is considerably improved.

The schematic diagram of a general pattern recognition system is shown in Exhibit B-6. The function of the system is to yield a decision which identifies or classifies the input patterns. For example, these input patterns could be a series of multispectral images, and the required classification task could be to identify regions in the images according to whether they are urban or rural.

The measurement device is generally considered to be the transducer which transforms the input patterns into a form suitable for machine manipulation. For example, in the case of images, this device is a scanner which transforms an image into digital form. The reader should not confuse this measurement device with the device responsible for producing the pattern itself. Again, in the case of a multispectral image, a multispectral scanner produces the image, while the function of this scanner in the pattern recognition system is to transform images into digital form.

The preprocessor performs the function of digital noise suppression plus any other functions associated with raw data preprocessing. In

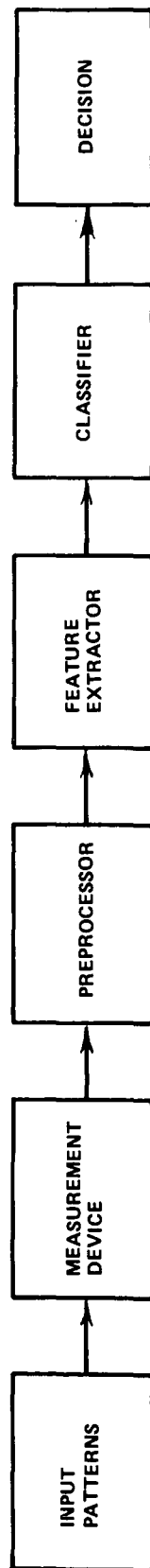


EXHIBIT B-6: GENERAL SCHEMATIC OF A PATTERN RECOGNITION SYSTEM

addition, it may perform specialized functions such as edge enhancement or line thinning.

The feature extractor is in charge of detecting features required for classification. Its function may be based on mathematical or statistical principles, but it very often simply consists of a set of ad hoc routines designed to perform a specific job.

The classifier is the decision maker. It uses the information provided by the feature extractor in order to perform decisions. Its structure may be based on mathematical or statistical principles as well as on ad hoc techniques. A combination of these approaches is not uncommon.

It should be emphasized that the "demands" on pattern recognition systems normally exceed their capabilities. The users of these systems often expect levels of performance well beyond the state of the art. Although the extensive research in this area will undoubtedly improve this situation, the planner of a pattern recognition system must above all be realistic and be fully aware of the state-of-the-art capabilities which may be achieved in the near future.

Based on the data rates with which we are being confronted, it is not difficult to conclude that we have no choice but to make use of present automatic data handling capabilities, and to intensify the research in areas related to this problem. It is safe to say that the success of an earth resources information system will be largely dependent on our ability to automatically process a great deal of the information handled by this system.

B-6 EXAMPLE OF AN AGRICULTURAL INFORMATION PROCESSING SYSTEM

The following is a brief description of the LARSYS (Laboratory for Agricultural Remote Sensing System) of Purdue University [32]. This system includes data collection via remote sensing of agricultural resources, processing of that data and distribution of the resulting information to scientist users.

The scope of the data collection includes laboratory, field, aircraft and satellite data. The main portion of the data processing is concerned with the development of pattern recognition techniques which show promise for agricultural applications. These areas of attention include feature selection, training sample selection, delineation of categories, and pattern classification by algorithms applicable to high data volume.

Regarding feature selection, an algorithm has been implemented for determining an optimal set of features. In addition, a sizeable amount of statistical data including histograms of selected features is compiled. Classification results are available from the processing facilities within 31 hours after Purdue receives the data.

Other areas of processing include algorithms for (a) automatic alignment or overlay of images of the same scene via different spectral channels, (b) boundary enhancement to aid in the overlay problem, and (c) differentiation of imagery to aid in boundary enhancement.

User-system interaction has been emphasized insofar as information distribution is concerned. Thus, most of the processing software is written in a high level compiler language (Fortran IV) so that system modifications may be made quickly.

B-7 INFORMATION VS. DATA

A layman's distinction might be that information is what you get from processing data, as was suggested by [33]. However, information processing professionals need a more technical definition. Information, or more precisely the self information associated with an event, is computed from the logarithm of the inverse probability of an event, according to information theorists [34]. Thus

$$I = -\log p$$

where p is the probability and I is the information in bits when the logarithm is to base 2. For example, a perfect true or false question requires one bit of information to answer it. Most computers have memories with a fixed number of bits assembled to form a word, and contain thousands of these words.

A data item may be represented by one or more words. The simplest data items are integers and characters. However, large scale computers can process more advanced data items such as real numbers. Since the precision used may vary from one machine to another because of the different number of bits assigned to a word, results from the same calculation process may vary. As long as the error associated with a data item does not exceed specified limits, the same data item is still indicated. For example: if the data item was converted to a meter reading, as long as the needle does not appear to move, the same reading would be taken even though the value of the data item might have small errors.

The distinction between information and data may be applied to imagery. For example, suppose that an array of data items is displayed on an amplitude sensitive two-dimensional surface such as a TV-tube. As long as the display does not appear to change, small variations in the actual values of data items can be tolerated. In this last example there is a problem if the image is magnified. Thus the topic of precision of imagery data is closely related to the resolution in the source image and the amount of amplification.

Without a technical bias, the word information has a relative connotation. That is the same message may be more informative to one person than to another. The reader is referred to the literature for a detailed discussion of conditional information [34]. However, this difference in

interpretation of imagery, depending upon a person's knowledge and skill, complicates the resolution and precision requirements. Thus, one user may get the information he needs from a bulk processed picture whereas another user would require a precision processed image to get the same information.

B-8 INVESTMENT AND OPERATING COSTS FOR AN EARTH RESOURCES INFORMATION MANAGEMENT SYSTEM

There are a number of ways that one could obtain constraining values for initial investment costs and annual operating costs for ERISTAR. The procedure described here is based on projected economic benefits from an earth resources information program. The main idea is to have total system costs less than total benefits, or to have a Benefit/Cost ratio exceeding unity. The underlying assumption is that a system configuration that is within the investment and operating cost constraints obtained by this procedure will produce benefits approximating those assumed in deriving the bounding values.

Another important aspect of the cost constraint values is that they correspond to the level of operation of the ERISTAR system as it evolves over time. The procedure described herein provides for such evolutionary growth by considering several phases of system operation, each with a different capacity for tapping potential economic benefits. A recent study [42] concluded that the immediately obtainable economic benefits from using remote sensing of earth resources total \$1.4 billion annually. This figure will be used as a basis for deriving constraining values for investment and annual operating costs for an initial operational ERISTAR system. Another study [43] cited the potential net annual benefits from a fully operational system as \$59 billion. This latter figure will be used to derive the maximum permissible costs for ERISTAR beyond 1977.

Consider an initial operational system over the five year period 1973-1977. Assume that all of the projected annual benefits of \$1.4 billion can be realized through the initial ERISTAR configuration. Using a minimally acceptable Benefit/Cost ratio of 2.5, the maximum allowable total annual cost (TAC) is \$560 million. Now the total annual cost is comprised of annual operating costs (AOC), which consists of factors for materials, labor, and capital, plus amortization of the initial investment (IV). Using a discount rate of 7% for the five year period, the fraction of the initial investment amortized in each year is 0.2439. Hence,

$$TAC = 0.2439 \times IV + AOC$$

There is no clear indication as to how much will be required to operate the system, but we can assume that the ratio of annual operating costs to amortized initial cost should be roughly unity. Then,

$$TAC = 0.2439 \times IV + \$280 \text{ million}$$

and

$$0.2439 \times IV = \$280 \text{ million}$$

or

$$IV = \$280 \text{ million} / 0.2439$$

or

$$IV = \$1.14 \text{ billion}$$

Thus, the constraining values for initial investment cost and annual operating cost are \$1.14 billion and \$280 million, respectively, for the initial five year period of operation.

Consider that the ERISTAR system will grow in capability such that in the five year period 1978-1982 about 10% of the potential total net annual benefits of \$59 billion can be realized. Hence, the net annual benefits would be \$5.9 billion. Using the Benefit/Cost ratio of 2.5, the maximum allowable total annual cost would be \$2.36 billion. Assuming that one-half of this cost is in annual operating cost, the maximum initial investment in the intermediate system is,

$$IV = \$1.18 \text{ billion} / 0.2439$$

or

$$IV = \$4.84 \text{ billion}$$

Consider the 10 year period 1983-1992 in which an advanced ERISTAR system would be operational. Assuming that this advanced capability would enable realization of 30% of the potential benefits of \$59 billion, the net annual benefits would be \$17.7 billion. Again applying the Benefit/Cost ratio of 2.5, the permissible total annual cost could reach \$7.08 billion. With one-half of this total applied to amortization, the maximum initial investment in 1982 to establish this fully operational ERISTAR system is,

$$IV = \$3.54 \text{ billion} / 0.1424$$

or

$$IV = \$24.86 \text{ billion}$$

Note that the fraction of initial cost amortized is 0.1424 over a ten year period.

While these values appear to be substantially higher than one might imagine being invested in an ERISTAR system, they nevertheless provide upper bounds for investment and annual operating costs that are

commensurate with the projected economic benefits from ERISTAR. Exhibit B-7 summarizes these constraining values.

B-9 NASA DATA PROCESSING FACILITY

Consider in detail the Earth Resources Technology Satellite (ERTS) data handling program. The National Aeronautics and Space Administration (NASA) has set up a Ground Data Handling System (GDHS) at its Goddard Space Flight Center in Greenbelt, Maryland [5]. There they have installed a NASA Data Processing Facility (NDPF) to handle the transformation functions. These functions are illustrated in Exhibit B-8, below.

The data is transmitted via a broadcast signal to receiving stations on the ground as telemetry data. The information is recorded and sent to the NDPF. Here it is first bulk processed, corrected, and annotated for future reference. This includes geometric, radiometric and video system corrections, as well as framing so all sensors are spatially coincident. The results are latent images on 70 millimeter film that can be processed and high density digital tapes that are computer-compatible.

Some of the bulk-processed film data will be sent to precision processing for further refinement. Here, further geometric and radiometric corrections are made, precision location and scaling are done to pinpoint the data relative to map coordinates. The output is a 9 1/2 inch film format, converted via a hybrid analog-to-digital system, and high density digital tape.

A very small amount of data will be sent to special processing for specific, special requirements. In addition, a photographic processing facility produces the 70 millimeter and 9 1/2 inch latent film images, enlarges and processes negatives, prints internegative and interpositive images, prints and processes sets for the generation of composite negatives, and duplicates and processes positive transparencies and paper prints. It also generates color composite negatives, color transparencies, and color prints. Finally, a microfilm processing function exists for the preparation of microfilm output of the 9 1/2 inch prints. A negative is kept of the exposed microfilm, with a processed positive sent to the users on demand.

The NDPF has been designed to produce controlled quality data and photographic images telemetered from ERTS and to disseminate them to users/agencies and to the more than 300 principal investigators from 43 states, the District of Columbia, and 31 foreign countries. According to Exhibit B-9, the NDPF inputs up to 9212 images per week, including black and white positive and negative transparencies, black and white and color prints, and color transparencies. Magnetic taped image data are also duplicated and distributed. The NDPF is organized into three major subsystems: (1) the Initial Image Generating Subsystem (IIGS); (2) the Scene Correcting Subsystem (SCSS); and (3) the Digital Subsystem (DS). The IIGS produces corrected 70 mm images of video data from either the return beam vidicon (RBV) camera video tapes, the multispectral scanner

<u>Period</u>	Costs (\$ billions)		
	<u>1973-1977</u>	<u>1978-1982</u>	<u>1983-1992</u>
Initial Investment	1.14	4.84	24.86
IV Amortization	0.28	1.18	3.54
Annual Operation Cost	0.28	1.18	3.54
Total Annual Cost	0.56	2.36	7.08

**EXHIBIT B-7: CONSTRAINING VALUES FOR INITIAL INVESTMENT AND
ANNUAL OPERATING COSTS FOR ERISTAR**

NDPF PRODUCTION REQUIREMENTS

RBV

SCENES PER WEEK	FOR EACH SCENE	ITEMS PER WEEK
1316	3 B-W	3,948
	30 + (9.5 INCH)	39,480
	30 - (70 MM)	39,480
	30 + (70 MM)	39,480
	30 + PRINTS (9.5 IN.)	39,480
263	1C -	263
	10C +	2,630
	10C PRINTS	2,630
66	3 B-W	198
	30 -	1,980
	30 +	1,980
	30 + PRINTS	1,980
	1C -	66
	10C +	660
1% BULK 13.2 5% PREC 66	10C PRINTS	660
	4 TAPES (3 COPIES)	158
	4 TAPES (1 COPY)	264

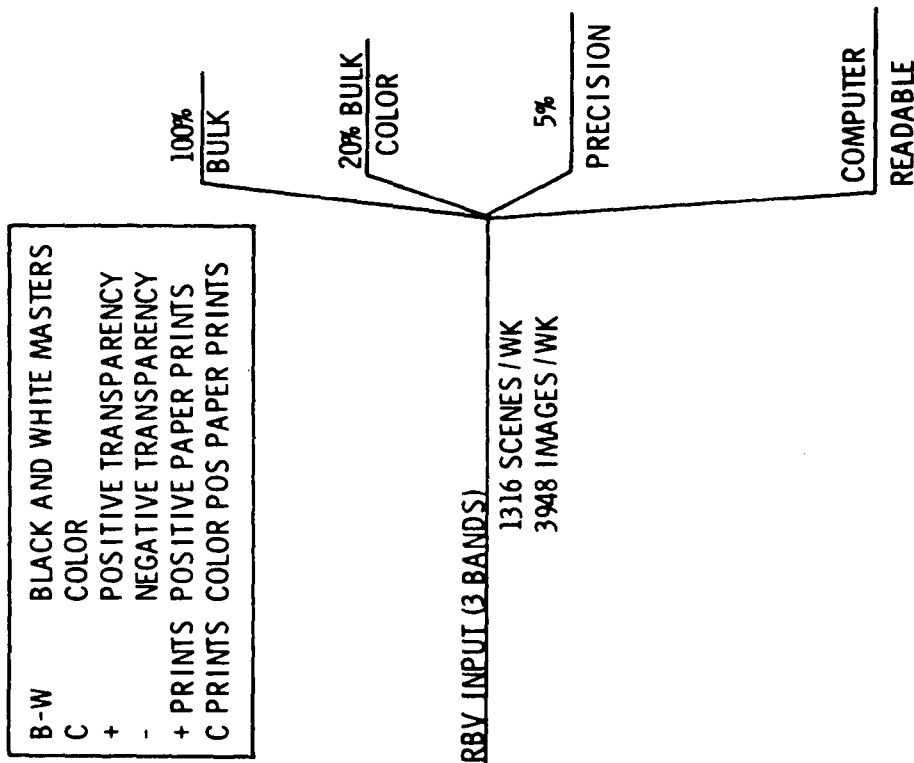
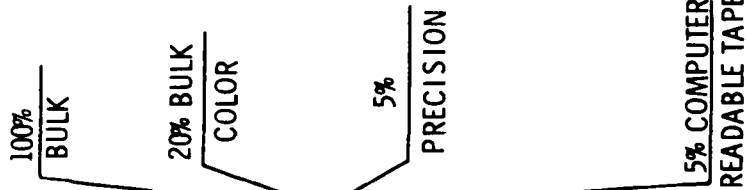


EXHIBIT B-9: GDHS THROUGHPUT REQUIREMENTS

NDPF PRODUCTION REQUIREMENTS

MSS

<div> <div> <div> <div>B-W</div> <div>C</div> <div>+</div> <div>-</div> <div>+</div> <div>C</div> </div> <div> <div>BLACK AND WHITE MASTERS</div> <div>COLOR</div> <div>POSITIVE TRANSPARENCY</div> <div>NEGATIVE TRANSPARENCY</div> <div>POSITIVE PAPER PRINTS</div> <div>COLOR POS PAPER PRINTS</div> </div> </div> </div>		SCENES PER WEEK	FOR EACH SCENE	ITEMS PER WEEK
<div> <div>MSS INPUT - 4 BANDS</div> <div>1316 SCENES / WEEK</div> <div>5264 IMAGES / WEEK</div> </div>		1316	4 B-W 40 + (9.5 INCH) 40 - (70 MM) 40 + (70 MM) 40 + PRINTS (9.5 IN.)	5,264 52,640 52,640 52,640 52,640
		263	2 C - 20 C PRINTS 20 C +	526 5,260 5,260
		66	40 B-W 40 + 40 - 40 + PRINTS 2 C - 20 C + 20 C PRINTS	264 2,640 2,640 2,640 132 1,380 1,320
		BULK 66 PREC 66	4 TAPES (3 COPIES) 4 TAPES (1 COPY)	792 264



(MSS) video tapes, or from special processed sensor data. These images are developed in the NDPF photographic processing area and inspected for quality and cloud cover. Any necessary enlargements and printing are accomplished at this time. The SCSS accepts these 70 mm images produced by IIGS and produces corrected film images on a 24 cm format. This processing removes geometric distortions and performs precision location and scaling of the corrected video relative to map coordinates. The DS reads the high density digital tapes prepared by IIGS and SCSS and edits and formats this data onto computer-readable digital tapes for distribution to ERTS users. Copies of all ERTS imagery are forwarded to the U. S. Department of Interior's Earth Resources Observation Systems (EROS) data center in Sioux Falls, South Dakota, and to other federal agencies.

A series of user services that illustrates the organization function have been set up at the NASA facility. A standard catalog of each orbit of the satellite is planned, containing a standard outline map and a computer listing which tabulates the images taken on that orbit. A catalog for the United States and another one for the rest of the world are included. The catalog will index data by orbit, time of image, sensor spectral band, and degree of processing and form of output.

A cumulative image descriptor index is also planned. This will cover the entire image data bank as it grows. A standard vocabulary is suggested to maintain consistency and simplify information exchanges. A catalog of the data gathered from ground platforms in the Data Collection System (DCS) is planned. It includes information on platform identification, platform location, time of first and last transmission in the reporting period, total number of messages transmitted since its inception and in the reporting period, and primary user identification.

Finally, a browse facility will enable visitors to NDPF to examine and select needed materials. It includes data samples, microfilm, data, references, data catalogs, display services, and trained personnel who can help the users. It also includes computer query and search capabilities.

The immediate implication of the NDPF description is that the processing functions are vital ones. The ongoing operations in the facility consist of such things as the conversion of telemetry data into photographic images, the conversion of these images into photographs and prints to be disseminated to the users, and converting the data into computer-compatible (machine readable) high density digital tapes. The form of the data can change, from input to storage as when the telemetered data is received and recorded on tape, and from storage to output, as when the microfilm negative master is processed for a positive output product.

APPENDIX C-1 CLASSIFICATION SCHEMES

Appli- cation	Code	Information	Frequency of Coverage	Data Perisha- bility(days)	Area Cover- age	Geometric Resolution (feet)
Agri- culture	A1	Farm-NonFarm				
	A2	Interface	yearly	1 - 10	regional	300 - 1000
	A3	Boundaries & Acreage	yearly	1 - 10	national	10 - 50
	A4	Base Maps	yearly	1 - 10	national	10 - 50
	A5	Crop Type	weekly	10 +	regional	300 - 1000
	A6	Crop Density & Vigor	weekly	1 - 10	regional	300 - 1000
	A7	Livestock Census	yearly	10 +	regional	10 - 50
	A8	Plant Stress Detection Disease or Insect Detection	weekly	1 - 10	regional	100 - 300
Cartog- raphy			daily	1/4 - 1	local	10 - 50
	C1	Mapping	yearly	10 +	global	10 - 50
Forestry	F1	Tree Types & Count	yearly	10 +	regional	100 - 300
	F2	Fire Detection	daily	1/4 - 1	local	100 - 300
	F3	Disease Detection	daily	1/4 - 1	local	100 - 300

Agricultural crops	Timber stands
Crop type (species and variety)	Timber type (species composition)
Present crop vigor and state of maturity	Present tree and stand vigor by species and size class
Prevalence of crop-damaging agents by type	Prevalence of tree-damaging agents by type
Prediction of time of maturity and eventual crop yield per acre by crop type and vigor class	Present volume and prediction of probable future volume per acre by species and size class in each stand
Total acreage within each crop type and vigor class	Total acreage within each stand type and vigor class
Total present yield by crop type	Total present and probable future yield by species and size class
Rangeland forage	Brushland vegetation (mainly shrubs)
Forage type (species composition)	Vegetation type (species composition)
Present range readiness (for grazing by domestic or wild animals	Vegetation density
Prevalence of forage-damaging agents (weeds, rodents, diseases, etc.) by type	Other types of information desired will depend upon primary importance of the vegetation (whether for watershed protection, game habitat, esthetics, etc.)
Present animal-carrying capacity and probable future capacity per acre by species and range condition class in each forage type	
Total acreage within each forage type and condition class	Same as above
Total present and probable future animal-carrying capacity	Same as above

EXHIBIT C-2: USER REQUIREMENTS FOR VEGETATION RESOURCE DATA: TYPE OF INFORMATION DESIRED [4]

Agency or group	Agricultural crops	Timber stands	Rangeland forage	Brushland Vegetation
Federal Agencies	Agricultural Stabilization and Conservation Service; Cropland Conservation Program; Conservation Reserve Program; Agricultural Conservation Program; Emergency Conservation Measures Program; Commodity Credit Corp.; Agricultural Marketing Service; Statistical Reporting Service; Economic Research Service; Soil Conservation Service; Federal Crop Insurance Corp.; Farmers Home Administration; Rural Community Development Service; Foreign Agricultural Service; Famine Relief Program; Foreign Economic Assistance Program; Department of Commerce Agricultural Census Program	U. S. Forest Service; Bureau of Land Management; plus many Federal agencies listed in Col. 2	U. S. Forest Service Bureau of Land Management; plus many Federal agencies listed in Col. 2	Primarily U. S. Forest Service and Bureau of Land Management
State and county agencies	Agricultural Extension Service; State Tax Authority	Division of Forestry; Forest Extension Service; State Tax Authority	Livestock Reporting Service; Range Extension Service; State Tax Authority	Division of Forestry; Division of Beaches and Parks; Water Resource Agency; State Tax Authority
Private groups	Producers of fertilizers and pesticides; crop harvesting industry; food processing and packing industry; transportation industry; food and fiber advertising and marketing industry	Producers of fertilizers and pesticides; logging industry; wood processing industry; transportation industry; wood products advertising and marketing industry	Producers of fertilizers and pesticides; meatpacking industry; tanning industry; transportation industry	Hunting and Fishing clubs; public utilities commissions; local irrigation districts

EXHIBIT C-3: USER REQUIREMENTS FOR VEGETATION RESOURCE DATA: AGENCIES AND GROUPS DESIRING THE INFORMATION [4]

Time Interval	Agricultural crops	Timber Stands	Rangeland forage	Other vegetation (mainly shrubs)
10 to 20 min.	Observe the advancing waterline in croplands during disastrous floods. Observe the start of locust flights in agricultural areas. Map perimeter of ongoing floods and locust flight. Monitor the wheat belt for outbreaks of blackstem rust due to spore showers.	Detect the start of forest fires during periods when there is a high fire danger rating. Map perimeter of on-going forest fires	Detect the start of rangeland fires during periods when there is a high fire danger rating. Map perimeter of on-going rangeland fires	Detect the start of brushfield fires during periods when there is a high fire danger rating. Map perimeter of on-going brushfield fires
10 to 20 hr.				
10 to 20 days	Map progress of crops as an aid to crop identification using crop calendars and to estimate date to begin harvesting operations.	Detect start of insect outbreaks in timber stands	Update information on range readiness for grazing	Update information on times of flowering and pollen production in relation to the bee industry and to hay-fever problems
10 to 20 months	Facilitate annual inspection of crop rotation and of compliance with Federal requirements for benefit payments. Observe growth and mortality rates in orchards	Facilitate annual inspection of firebreaks	Facilitate annual inspection of firebreaks	Facilitate inspection of firebreaks
10 to 20 yr.	Observe shifting cultivation patterns	Observe growth and mortality rates in timber stands	Observe signs of range deterioration and study the spread of noxious weeds	Observe changes in edge effect of brushfields that affect suitability as wildlife habitat
20 to 100 yr.		Observe plant succession trends in the forest	Observe plant succession trends on rangelands	Observe plant succession trends in brushfields

NOTE: - Examples only are given. To convert this table to rapidity with which information is needed, use "half-life" concept. (See text.)

EXHIBIT C-4: USER REQUIREMENTS FOR VEGETATION RESOURCE DATA: FREQUENCY WITH WHICH THE INFORMATION IS NEEDED [4]

APPENDIX C-2 USER NEEDS SURVEY CONSIDERATIONS

Extracted from The Battelle Memorial Institute
Report to the Tripartite Committee-1969

"No information service should be allowed to operate on an 'on-line' basis without periodic self-assessment of its performance in light of its mission."

Therefore "continuing analysis of information and data uses and needs of the community to provide the basis for assessing the adequacy of existing sources of information and data and for improving them where required.

Ingenious research is sadly needed in the area of measurement of user information/data needs. There is no doubt that one of the most critical criteria of information services is detection of the actual needs of the users of such services - the detection of the real demand which the service must fulfill.

In determining user needs, there are three basic approaches:

- (1) The first approach involves asking the prospective users what services they need, which amounts to asking what they think they need.
- (2) The second approach is based on direct observation of the activities of the users as a means of deducing their needs for information.
- (3) The third approach involves retrospective study of experiences of users in applying information. "Demand studies", "critical incident studies", and "failure identification studies" are of this type.

While either the second or third approach, if conducted properly, can lead directly to the actual needs of the users, they are often less practical initially to what may be called expressed needs of the users.

The potential users, if asked (by means of questionnaires or interviews) what their needs are, will tend to form answers within a frame of reference built primarily on their observation of existing services - services which they have already seen in action. Because the user anticipates that the services he knows are the only ones existing, the answers received from questionnaires or interviews represent expressed needs that are one step removed from actual needs.

Referring to the exhibit following Appendix C-2, there seem to be two methods by which expressed needs may be converted to actual needs, and actual needs are a much more suitable basis for system design.

- (1) The first method involves some as yet unknown methodology which could be the subject for some very important research yet to be performed. Some effort (so far unsuccessful) has been made to accomplish this step by using questionnaires specially designed for

EXHIBIT C-5: USER NEEDS SURVEY CONSIDERATIONS

analysis by means of factor analysis. This would hopefull identify basic factors which affect the user's needs rather than merely extract expressed needs.

- (2) The second method involves an evolutionary type of approach. Questionnaires and interviews lead to the expressed needs of the users which form the basis for developing information services. After the users have had experience with the services, a second round of questionnaires or interviews will indicate how well the new services are serving the needs. This approach may be repeated as often as necessary to approach optimum design in an evolutionary manner. In a research program this second method could be used in validating the first method."

EXHIBIT C-5: (CONTINUED)

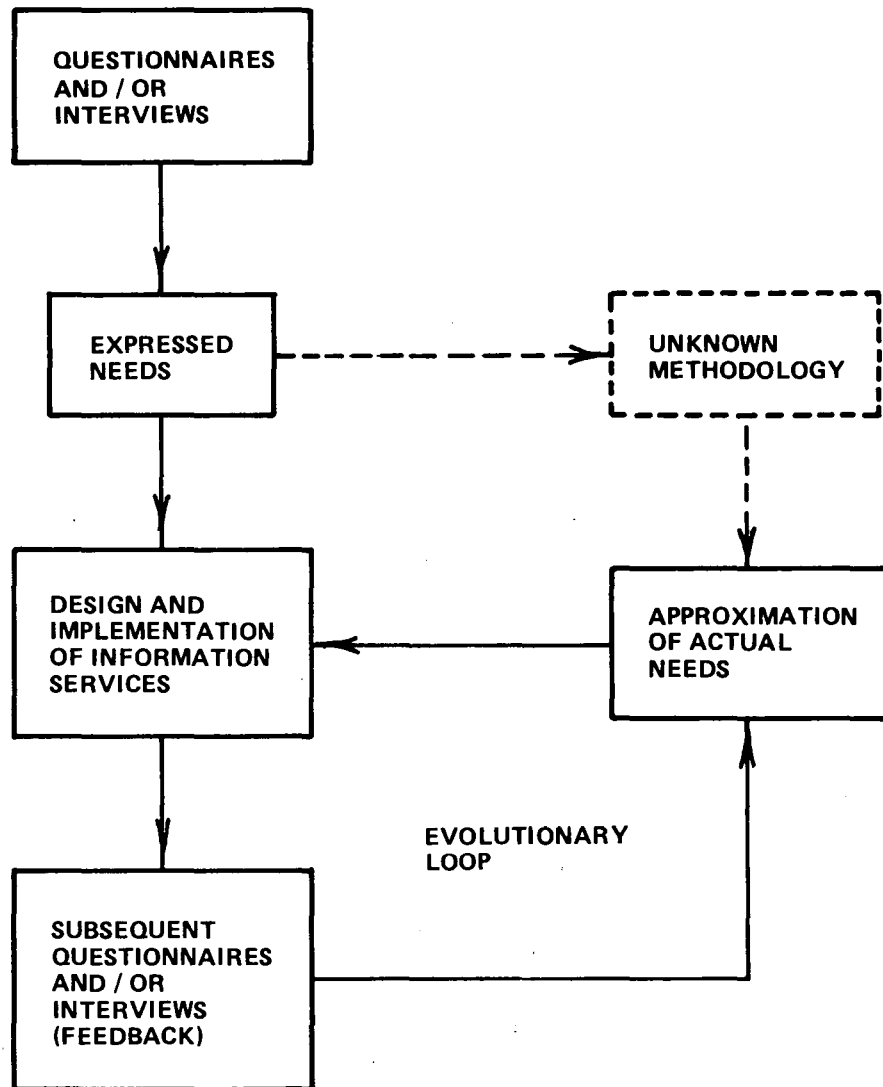


EXHIBIT C-6: THE ASKING APPROACH TO DETERMINING USER NEEDS

Appendix C-3

JOB DESCRIPTIONS

TITLE: User Research Analyst

- FUNCTIONS:
- (a) Performs analysis of user needs with respect to earth resource information,
 - (b) Determines user capabilities to interface with ERISTAR,
 - (c) Determines systems output criteria regarding content, format, display medium & response time,
 - (d) Summarizes & reports survey results to Systems Design Group,
 - (e) Presents preliminary systems design(s) to potential users for review,
 - (f) Acts as liaison between potential users and the designers of the system.

REQUIREMENTS:

EDUCATION

Bachelors Degree-BS
Diversified Background
(Earth Science, Urban Planning, Management, Computer Science)

SKILLS

Analytical
Facility in written and oral communication
Good listener
Adaptable

TITLE: Education Specialist

FUNCTION: (a) Develops material on ERISTAR for distribution to general users,
(b) Develops seminars on ERISTAR for general users,
(c) Presents material at conferences, seminars and work shops.

REQUIREMENTS:

EDUCATION BS Degree general background in science or engineering

SKILLS Facility in written and oral communications, willing to travel

TITLE: Training Specialist

FUNCTIONS: (a) Develops training material for teaching user for system hardware and system software,
(b) Develops training material for teaching the interpretation of the system output,
(c) Develops training material for teaching the application of ERISTAR data,
(d) Conducts training sessions.

REQUIREMENTS:

EDUCATION BS or MS degree in science or engineering

SKILLS Facility in written and oral communications

TITLE: Public Relations Representative

FUNCTIONS:

- (a) Creates promotional material,
- (b) Conducts public relations activities,
- (c) Acts as liaison between potential users and the ERISTAR system,
- (d) Develops prospective user relationships
- (e) Feeds back information from user to ERISTAR system.

REQUIREMENTS:

EDUCATION BS Degree (MS preferred)
Diversified background
(Marketing management, public relations)

SKILLS Facility in written and oral communication
Knowledge of information science

TITLE: User Inquiry Analyst

FUNCTIONS:

- (a) Analyzes referred user inquiries to determine information and source of same, and interviews user for clarification of need,
- (b) Makes decisions based on knowledge of ERISTAR capabilities and potentials,
- (c) Interfaces with Information Analysis Personnel for custom processing and analysis needs,
- (d) Determines center action to be taken on more complex requirements,
- (e) Has first line supervisory responsibility over user inquiry clerks.

REQUIREMENTS:

EDUCATION Bachelors Degree BS (MS preferred)
Desirable subjects:
(Computer Science, Information Science)

SKILLS Analytical
Interview techniques
Facility in written and oral communication

TITLE: User Inquiry Clerk

- FUNCTIONS:
- (a) Makes initial contact with User,
 - (b) Classifies inquiry as to routine or one requiring special handling,
 - (c) Assists User in search for source using standard catalog techniques,
 - (d) Displays output formats (typical) to Users.

REQUIREMENTS:

EDUCATION

High School
Additional training in:
Audio Visual Use
Photo Interpretation Appreciation
Library Cataloging

SKILLS

Good speaking voice
Interview techniques
Ability to meet the public favorably
Analytical

TITLE: User Service Representative

- FUNCTIONS:
- (a) Responsible for distribution,
 - (b) Assists User Inquiry Clerk on routine matters,
 - (c) Makes contact with User on distribution matters requiring special attention.

REQUIREMENTS:

EDUCATION

High School

SKILLS

Ability to meet the public

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APPENDIX D-1

16 ALTERNATIVE APPROACHES TO AN ERISTAR NETWORK

1. Nodes or centers are represented as

Federal authority over center ○

State authority over center △

Private authority over center □

Combination of symbols implies combination of authorities. ◻

2. Lines between nodes represent control, not communication (it is assumed that communication is possible between all nodes), and are shown as

Federal ———○—————○—————○—————

State ———△—————△—————△—————

Private ———□—————□—————□—————

Combination —————

3. Double lines between centers indicate controls are negotiated.

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GEORAPHIC
LEVEL

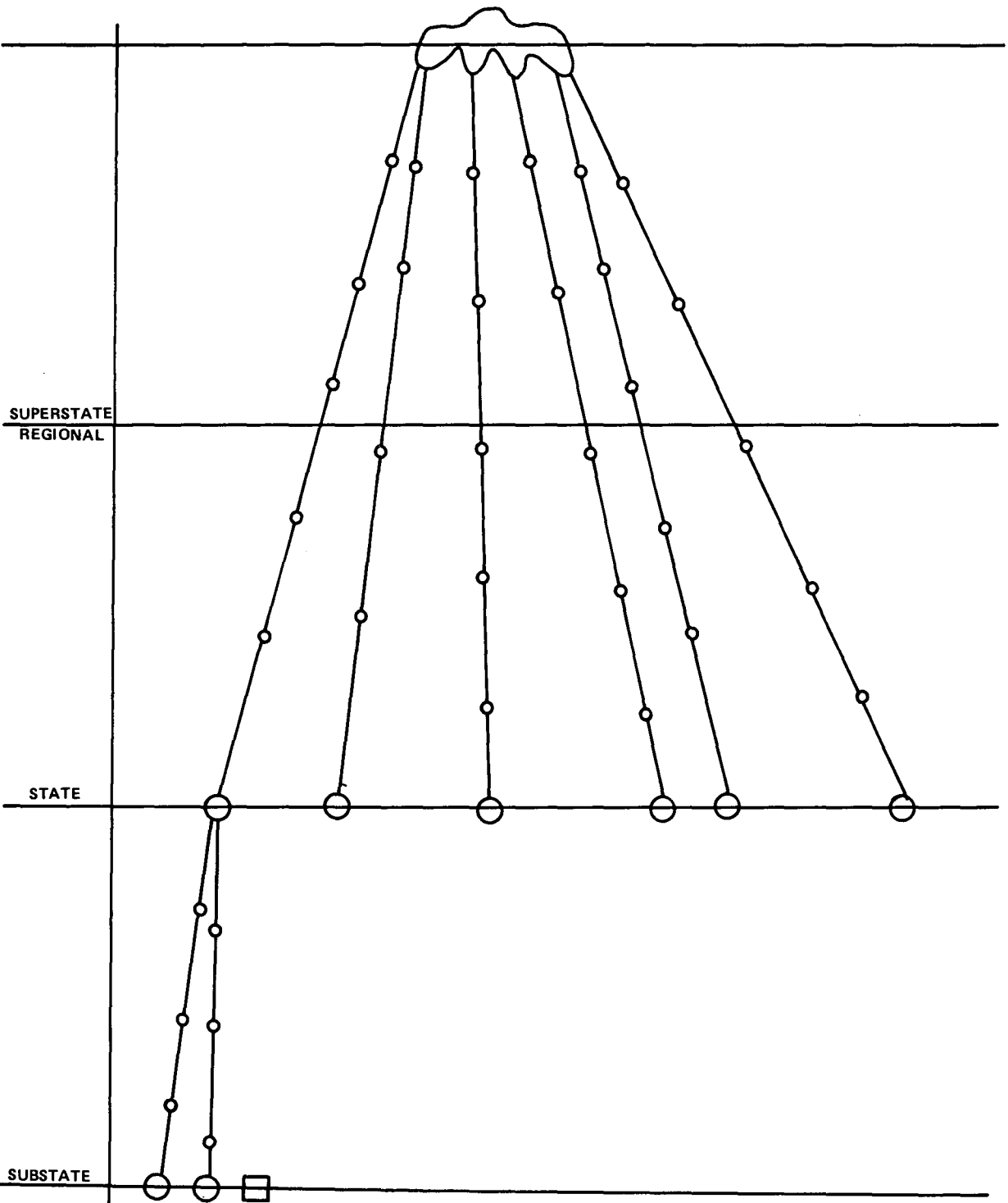


EXHIBIT D-1 16 ALTERNATIVE APPROACHES TO AN ERISTAR NETWORK

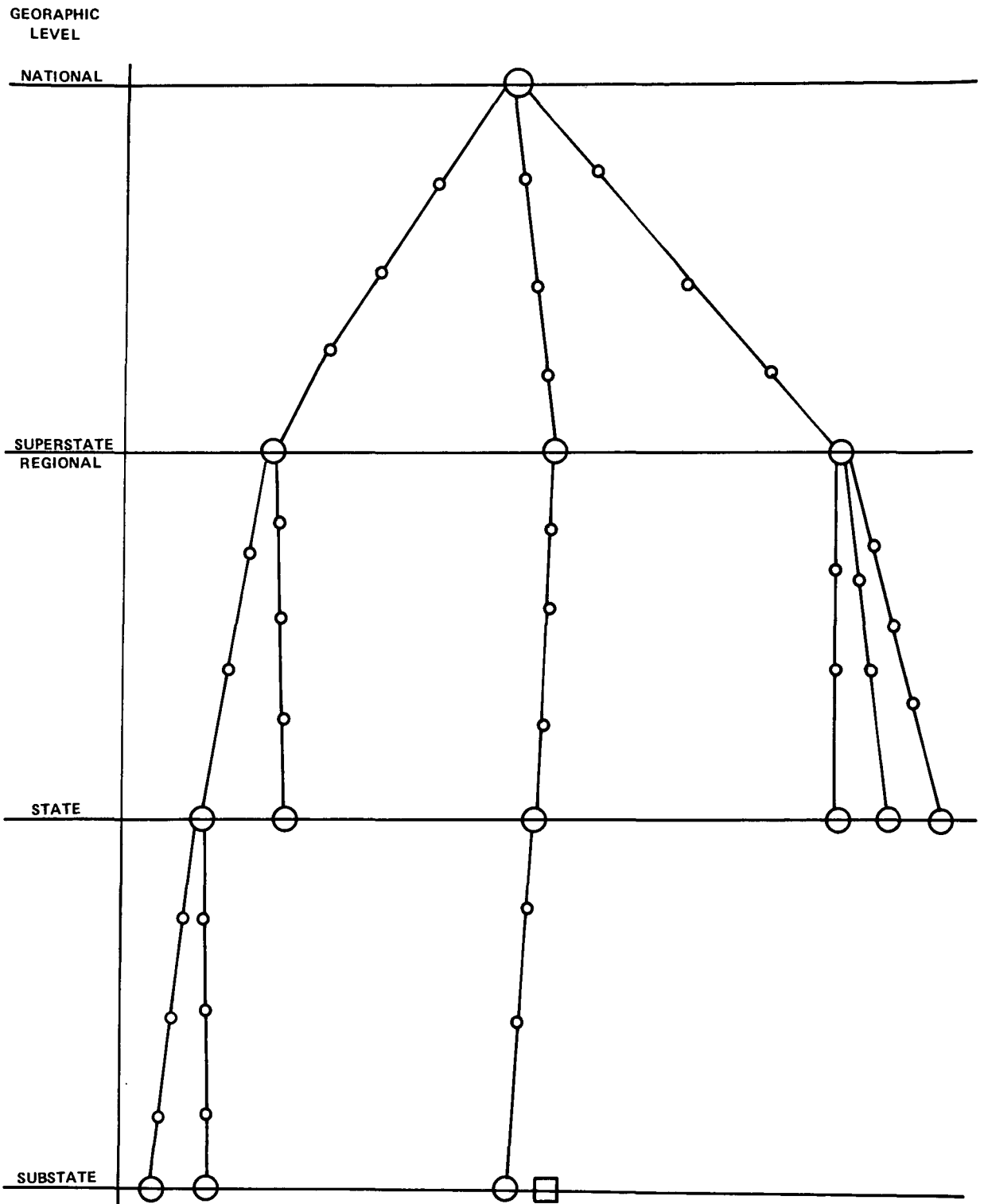


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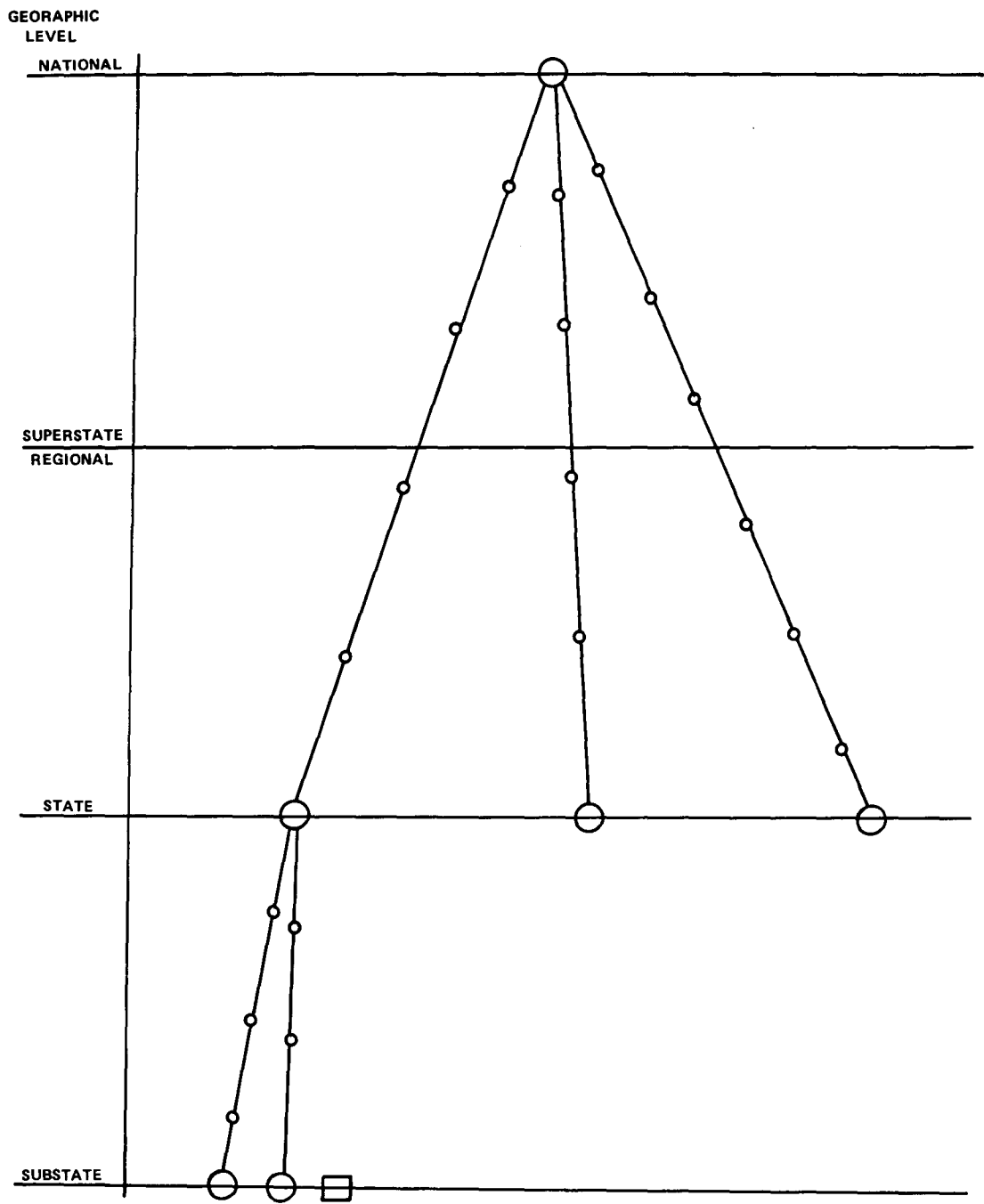
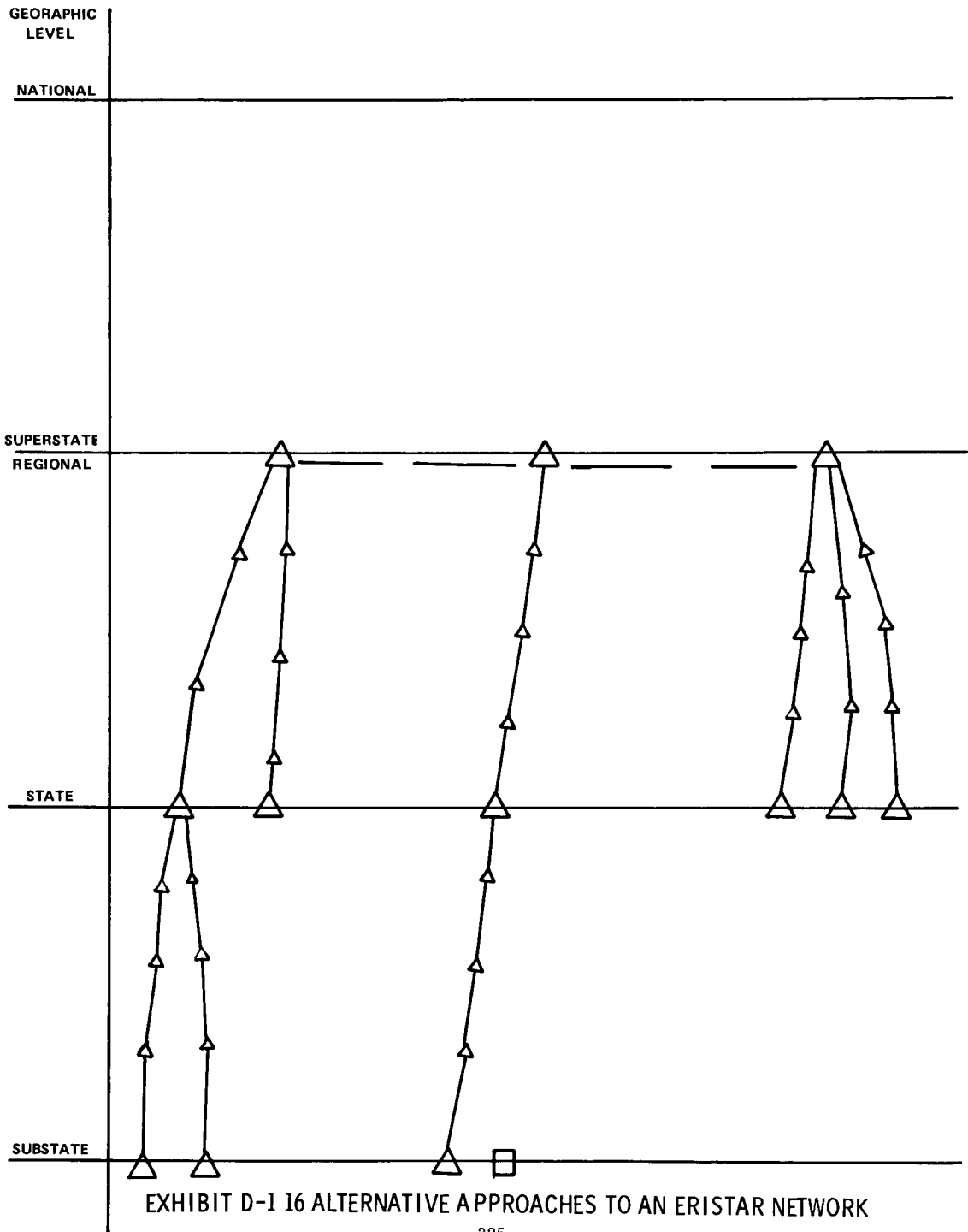


EXHIBIT D-1 16 ALTERNATIVE APPROACHES TO AN ERISTAR NETWORK



GEORAPHIC
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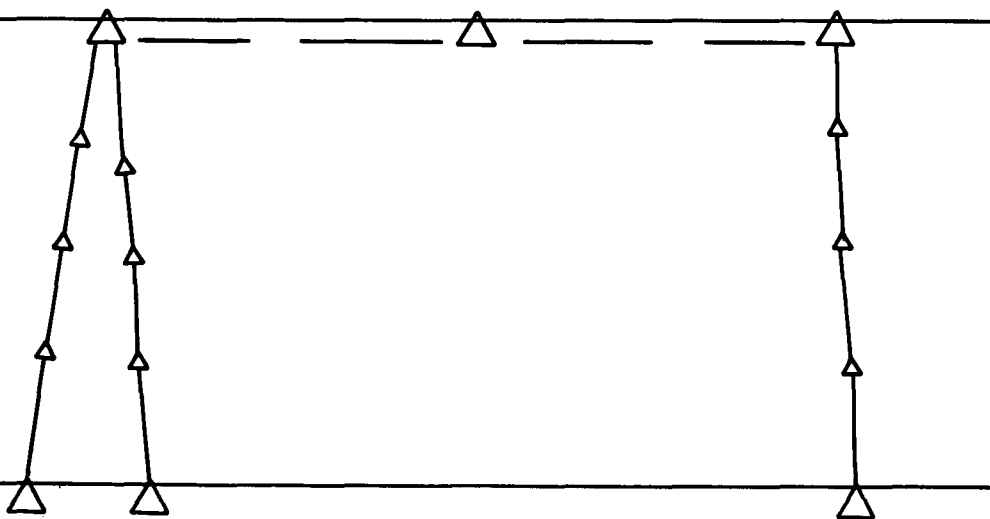
NATIONAL

SUPERSTATE
REGIONAL
SUPERSTATE
REGIONAL

STATE

28

EXHIBIT D-1 16 ALTERNATIVE APPROACHES TO AN ERISTAR NETWORK



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LEVEL

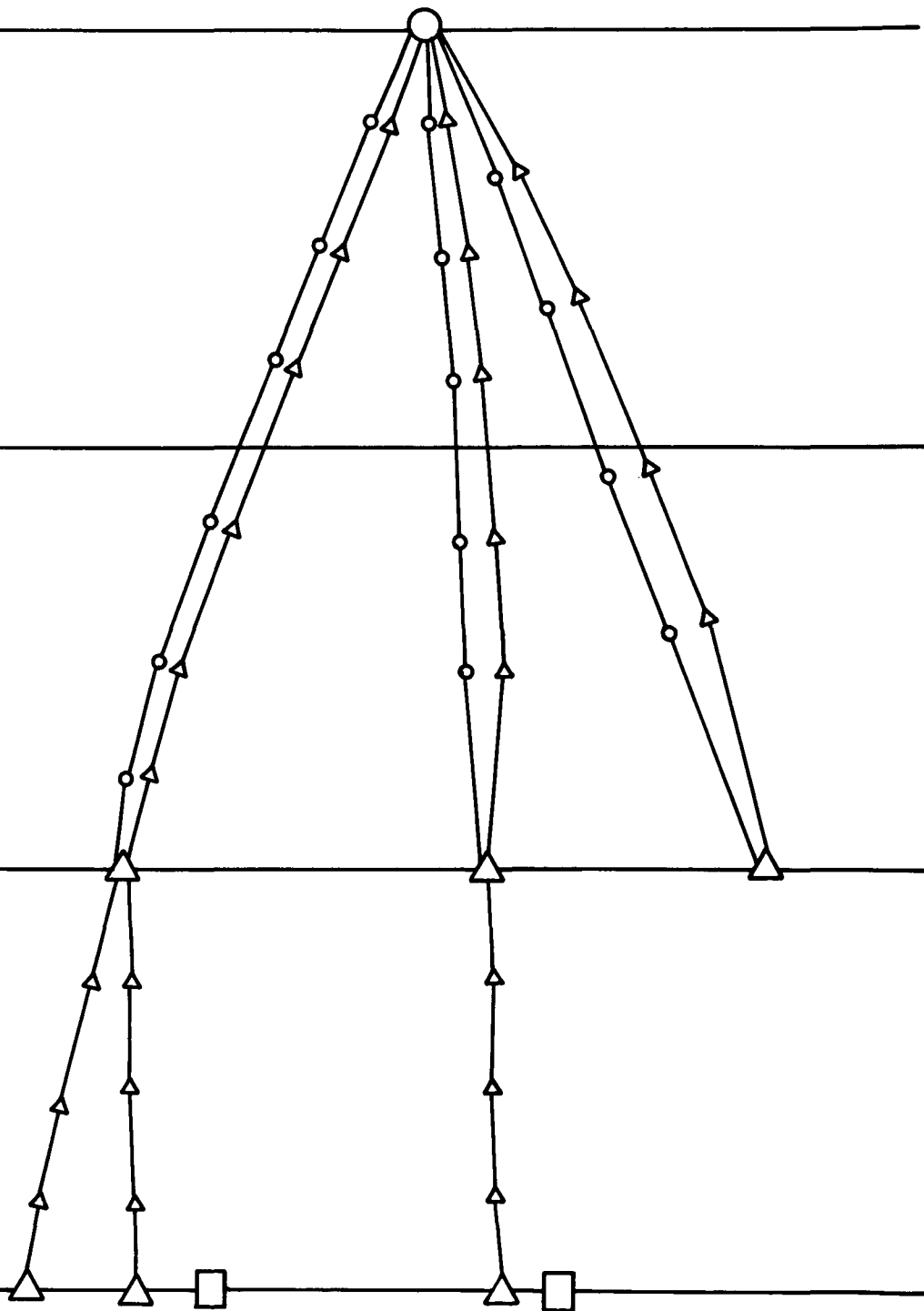
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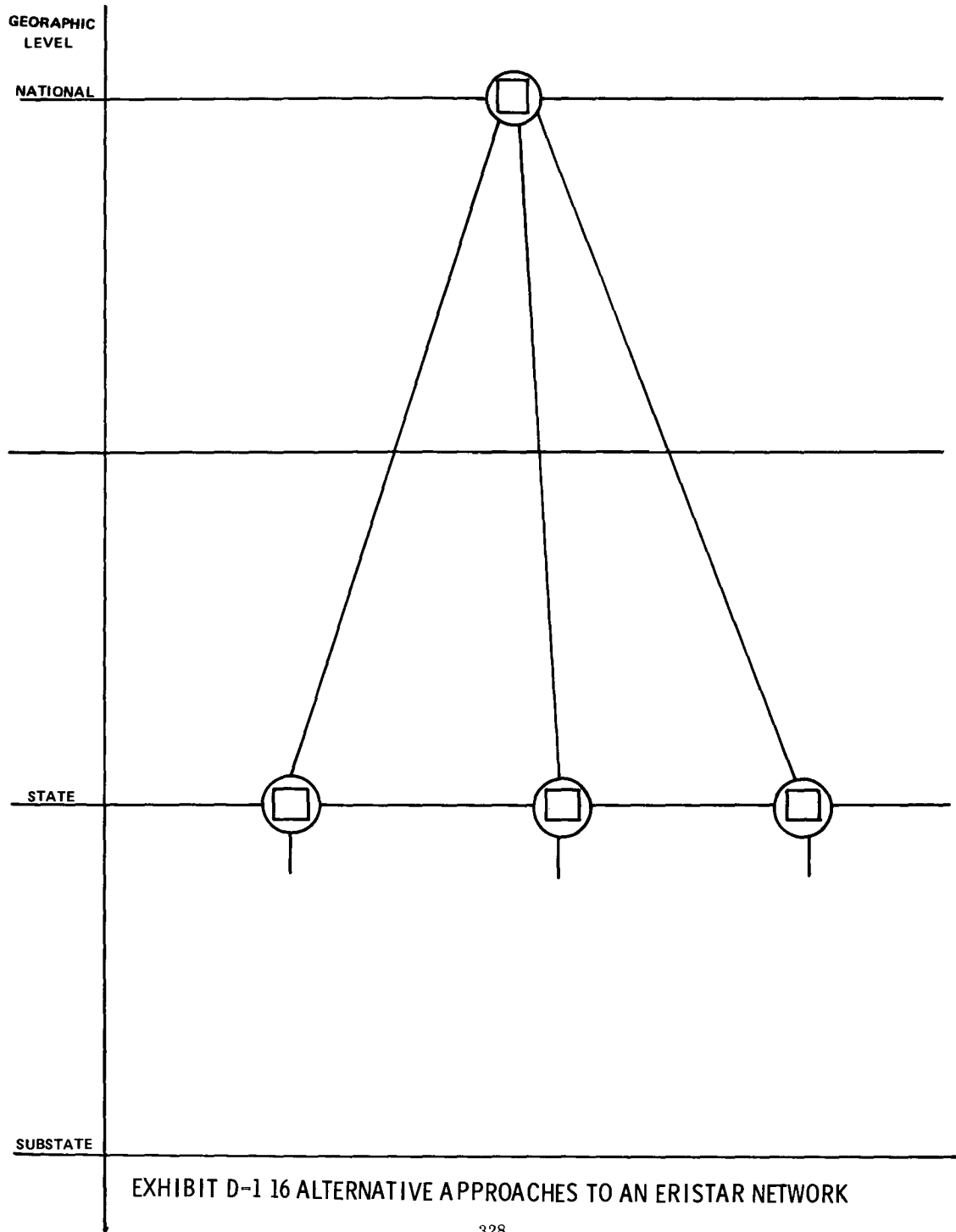
SUPERSTATE
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STATE

SUBSTATE

EXHIBIT D-1 16 ALTERNATIVE APPROACHES TO AN ERISTAR NETWORK





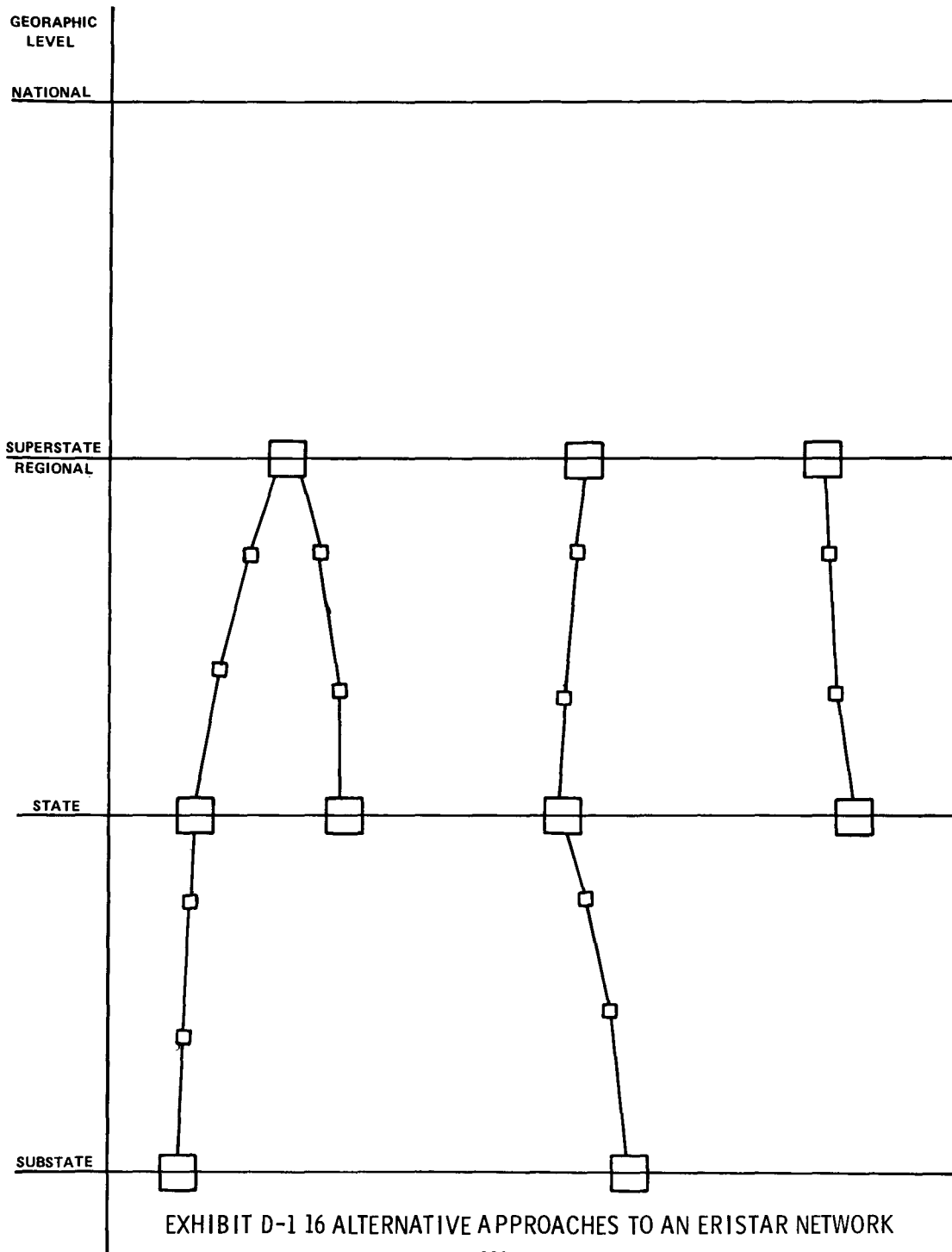
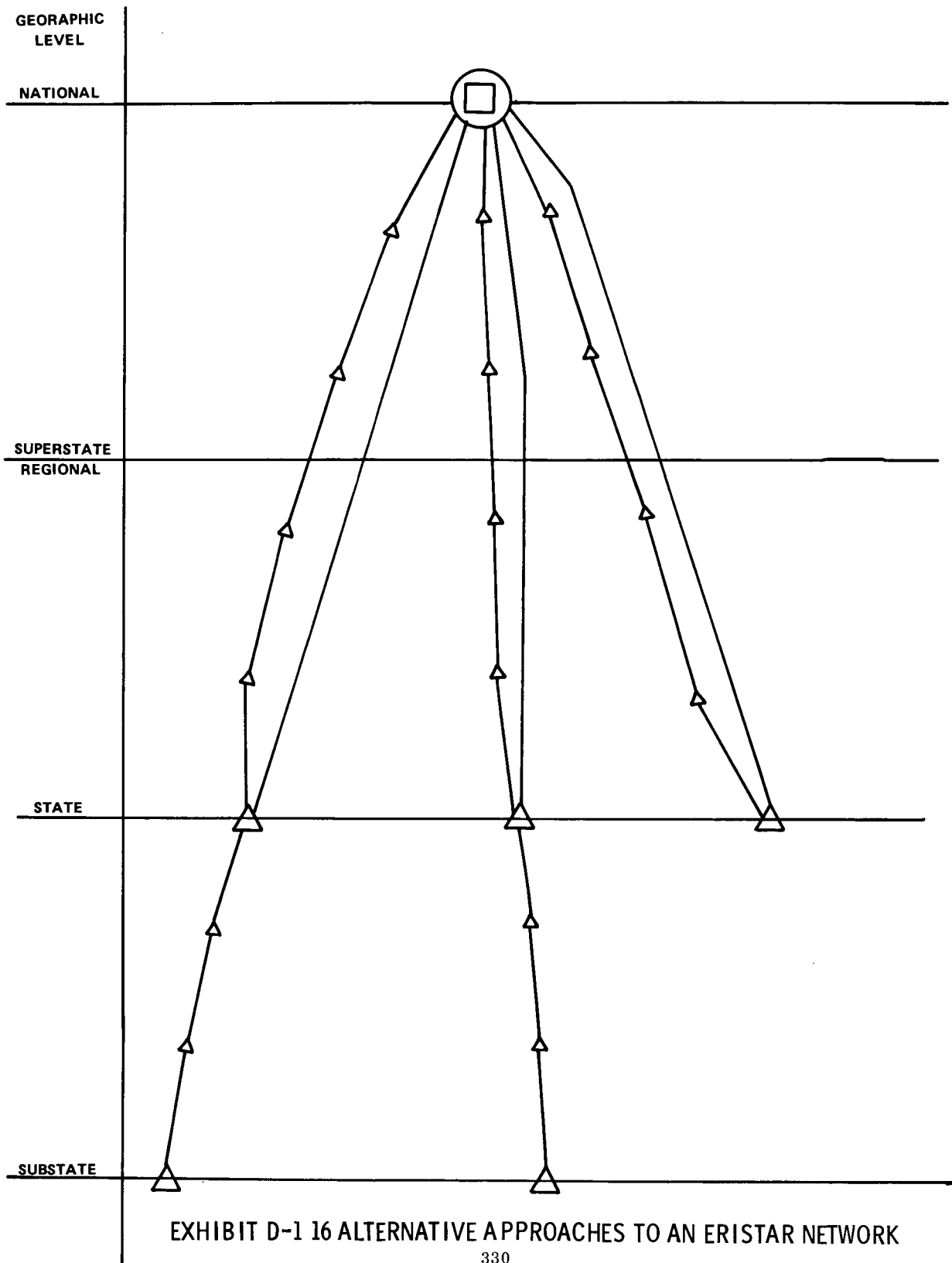
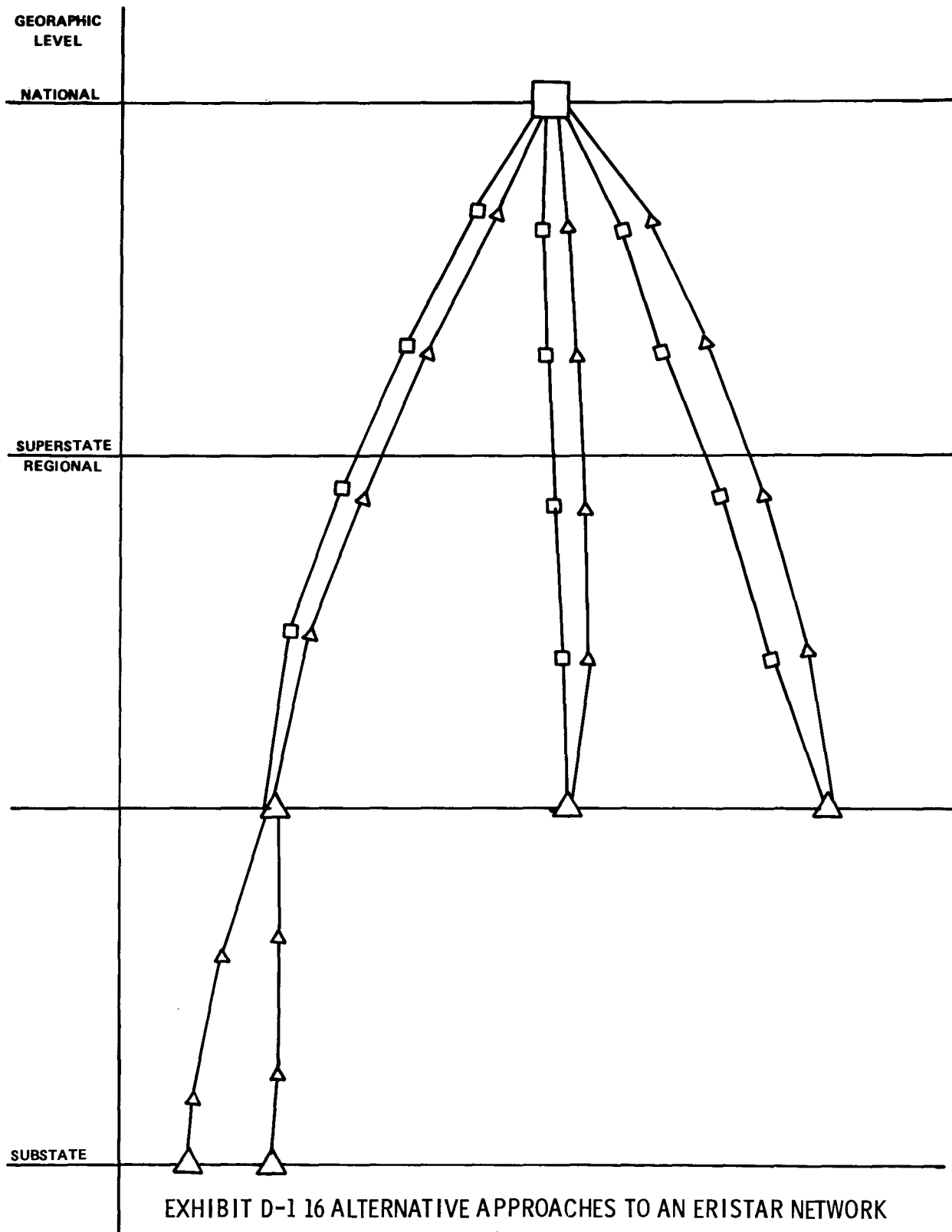
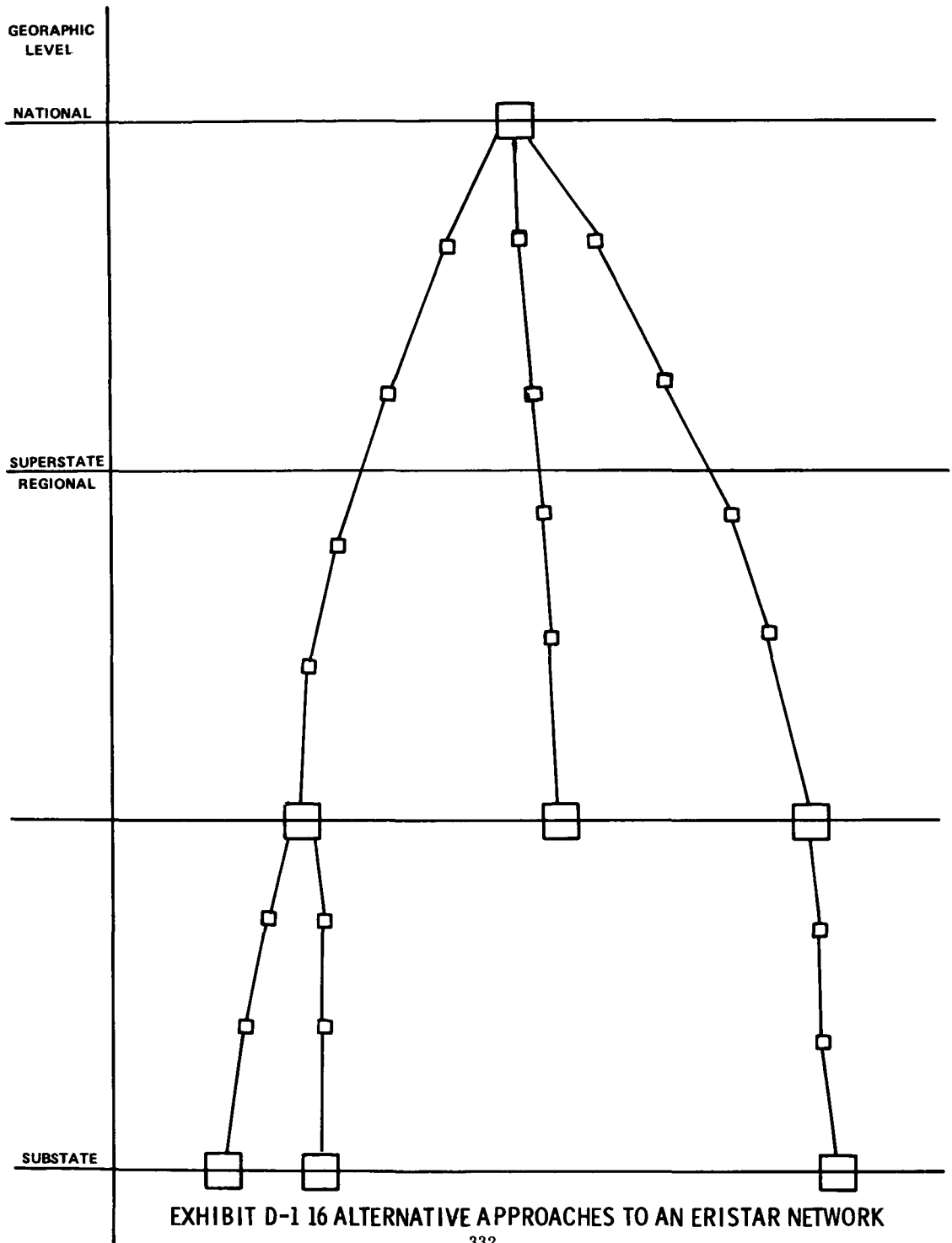
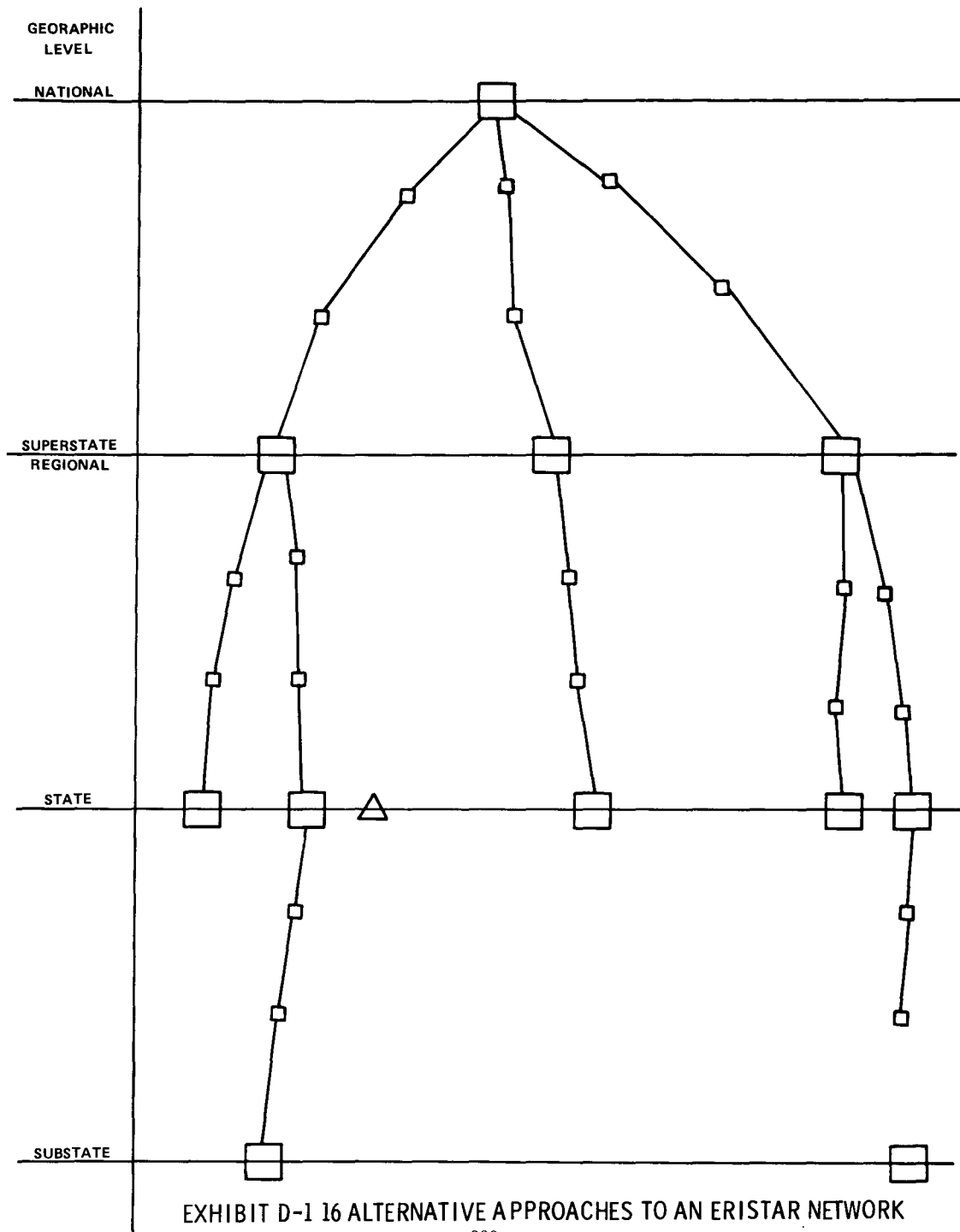


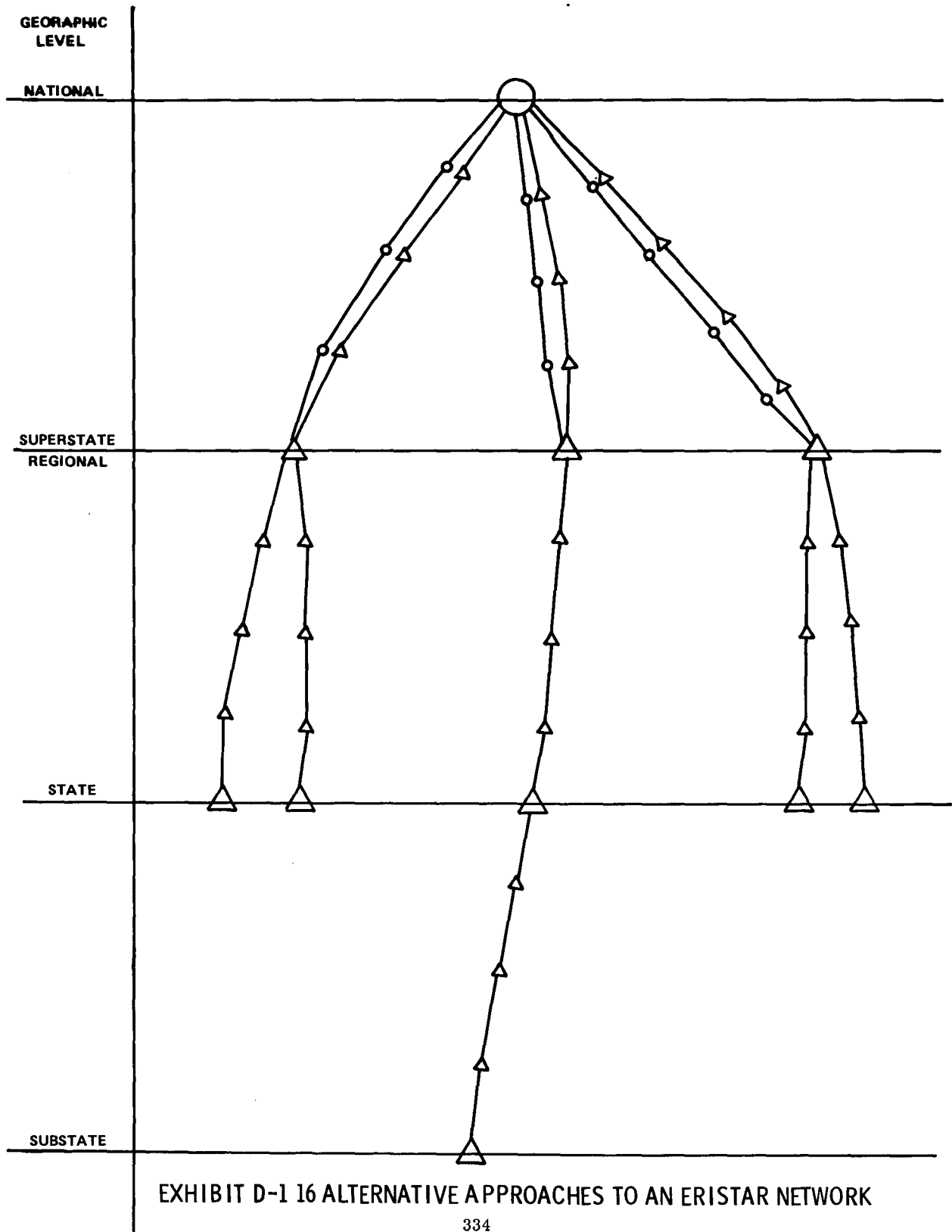
EXHIBIT D-1 16 ALTERNATIVE APPROACHES TO AN ERISTAR NETWORK

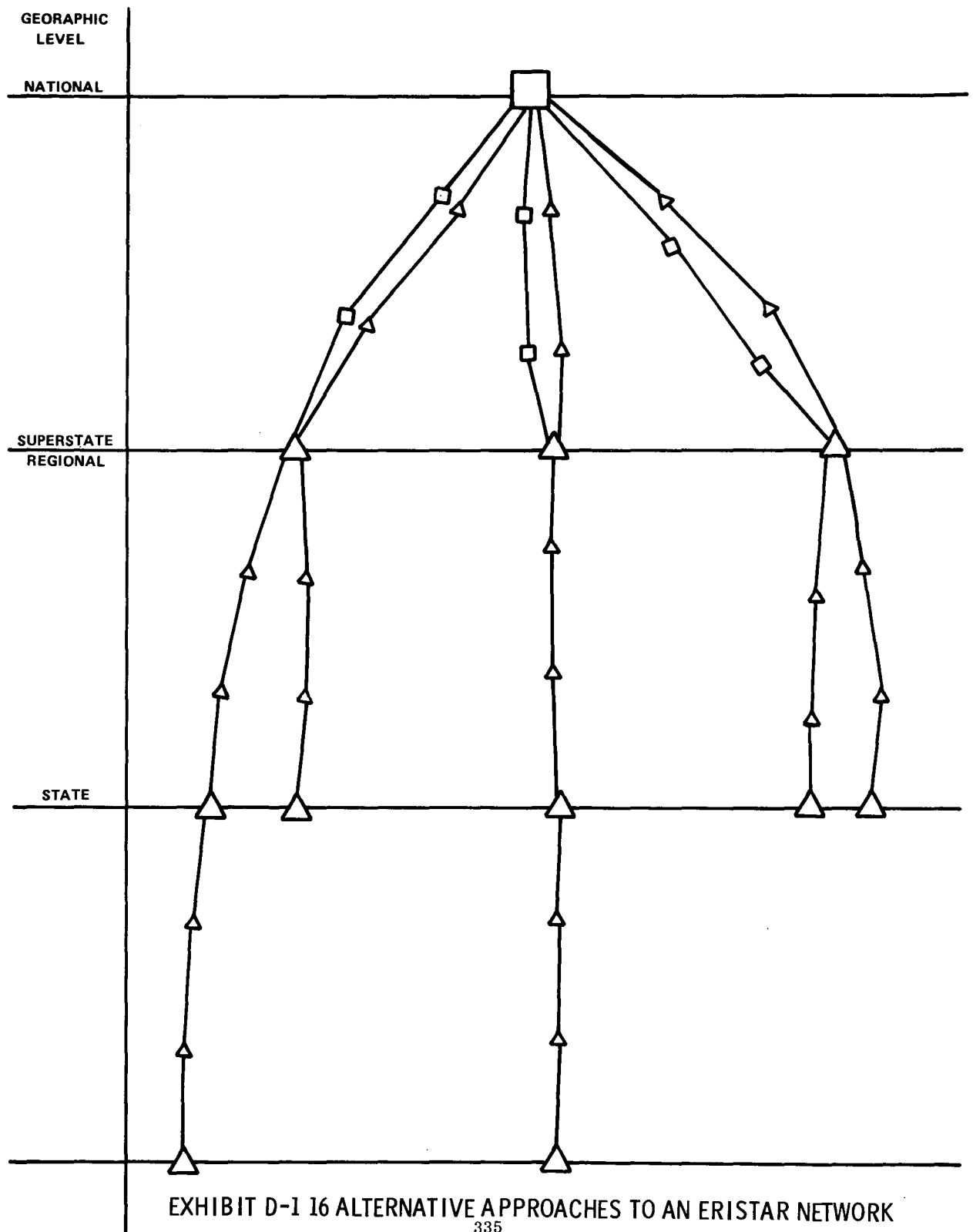


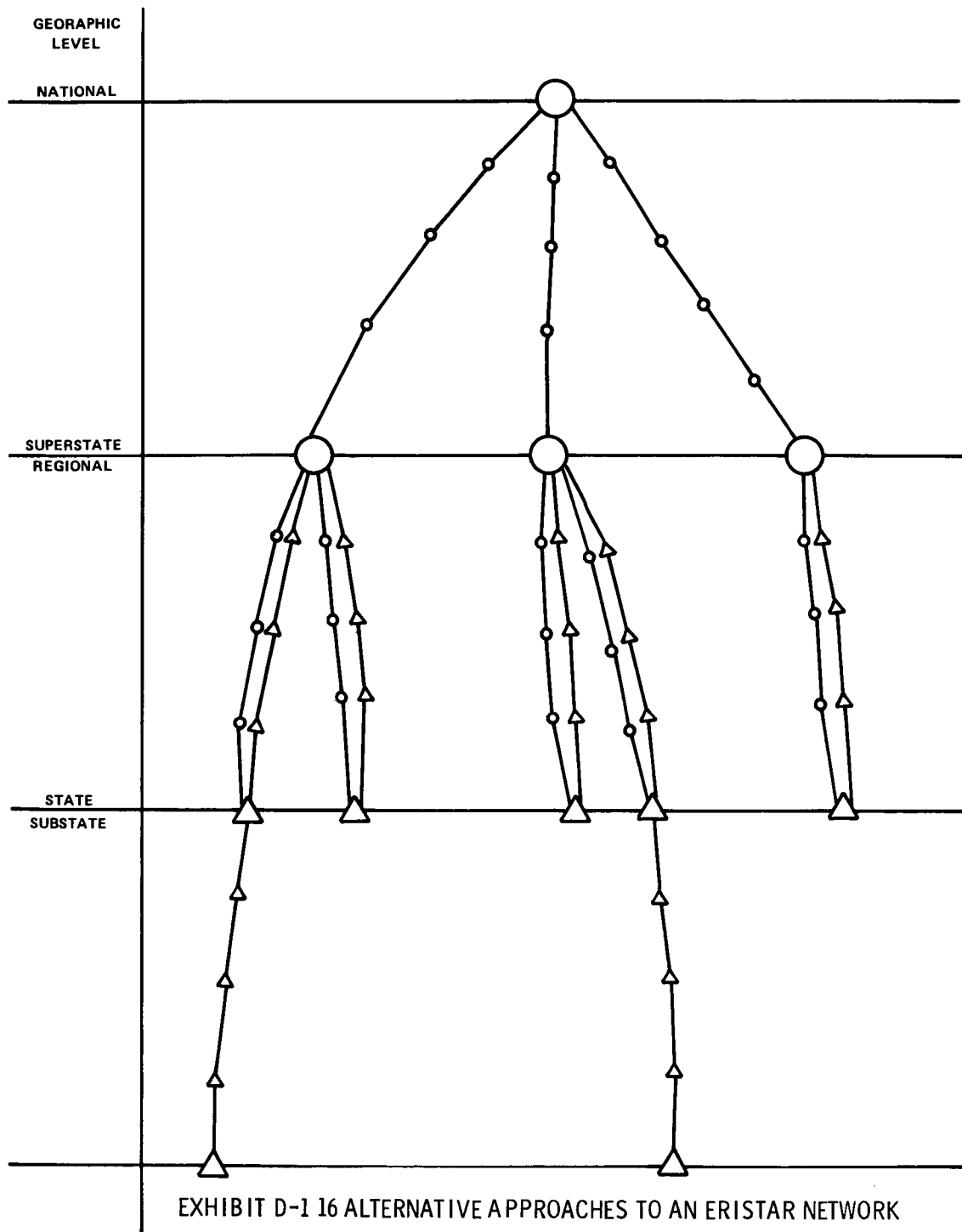












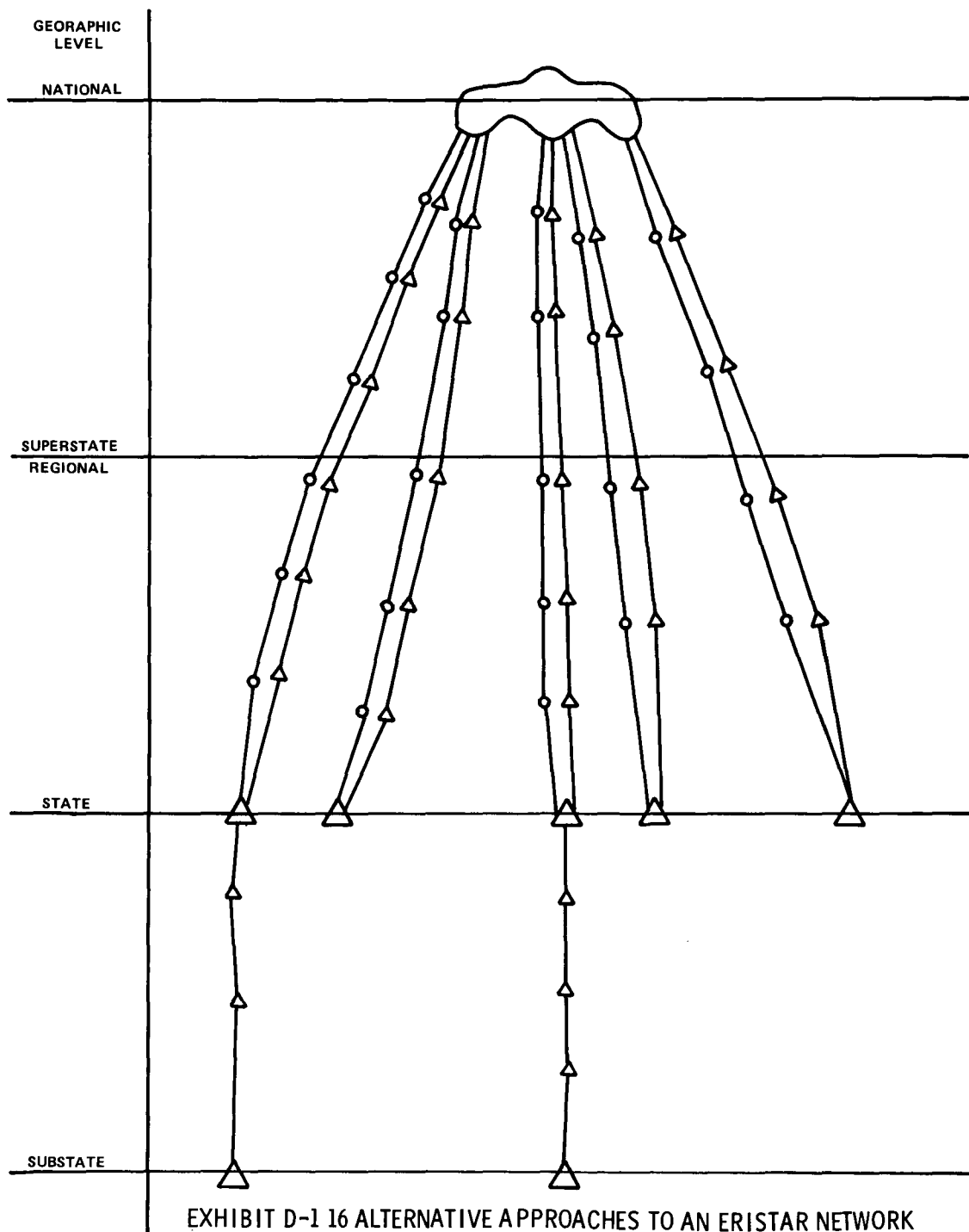


EXHIBIT D-1 16 ALTERNATIVE APPROACHES TO AN ERISTAR NETWORK

APPENDIX D-2

LIST OF MANAGEMENT RESPONSIBILITIES OF ERISTAR CENTER STAFF

General Manager

The center manager has ultimate responsibility for the operation of his center. It is his duty to set general operating policy, although he will probably rely heavily on his staff for advice before doing so. It is the manager's task to divide the center management responsibilities into two groups: (1) those administered by the manager and (2) those delegated to staff. The center manager should:

1. Give guidance to his staff with regard to delegated responsibilities and be sure that his staff is performing well.
2. Be directly responsible for the political and diplomatic aspects of interfacing his center with whatever other center or organizations he thinks appropriate.
3. Be directly responsible for setting center policy with regard to user and source priorities as well as user and source data security.
4. Be directly responsible for all other center functions not delegated to his staff.

The role of a center manager will change somewhat, depending on whether he is managing a federal, regional, state or sub-state center. It will be necessary for the center general manager to take direct responsibility for the management of an increasingly larger number of center functions as the size of the center and center staff decreases. If he is the manager of a subordinate center (i.e., sub-state or regional) he may not make policy so much as he will interpret policy handed down from superiors. On the other hand, center managers at the state and federal levels may be responsible for establishing policy for the subordinate sub-state and regional centers. The degree to which a center manager will make policy as opposed to interpret policy from his superiors will be determined by the state and federal agencies or organizations which are given ultimate responsibility for ERISTAR.

Assistant General Manager

The assistant general manager is responsible for those management duties delegated to him by the general manager. The organizational chart (Exhibit 5-6) suggests that all center managers and directors would be under the assistant general manager with the exception of the Research, Legal and Planning directors who report directly to the general manager. The assistant general manager position would probably not be staffed in smaller information centers.

Normal Staff Positions

Exhibit 5-6 shows the following staff directors: Research, Legal, Planning, Finance, Personnel & Support Service. These directors have a standard and well defined role in any modern organization. The functions which they manage are discussed in section 5.3.1 of this report.

Manager of Information Analysis and Processing

Most of the responsibilities of the manager of information analysis and processing are clearly implied by his title. He will interpret and implement center policy with regard to analysis and processing of information and will assure the efficient and effective functioning of this important center capability. An important part of his duties is to specify the information which must be obtained from sources outside the center, in order to meet the informational demands of the user.

Manager of Center and Network Operations

The center and Network Operations Manager has management of the data base as his most important responsibility. He must be certain that the data base is properly and appropriately updated. He must implement policy set by the general manager with regard to security. He must administer the acquisition of information specified earlier by the manager of information processing and analysis. He will see to it that interfaces negotiated by the general manager are implemented so that information will flow to the data base by phone, mail or direct computer hook-up. He will establish appropriate maintenance schedules for the equipment under his control (particularly computers). He will also be responsible for maintaining a center monitoring capability (MIS) in order to give the general manager the information which is vital for the efficient administration of the center as a whole.

Manager of User Services

The manager of USER Services is responsible for the administration of the contact of ERISTAR with its customers (users) and the public in general. It is his duty to assure that ERISTAR:

1. Has a good public image (public relations)
2. Advertises and distributes its product in the best way possible (marketing).
3. Educates the public about what ERISTAR is and educates the user about how to use ERISTAR.
4. Is easy for the user to access.
5. Deals with the user and his query in an efficient and effective manner.

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APPENDIX E-1

EDUCATIONAL BACKGROUNDS

FACULTY PARTICIPANTS

Berry, R. W.		
BS (1955)	Lafayette College	(Mining Engineering)
MA (1957)	Washington Univ.	(Geophysics)
Ph.D. (1964)	Washington Univ.	(Geochemistry)
Biles, W. E.		
BS (1960)	Auburn Univ.	(Ch. E.)
MS (1969)	Univ. of Alabama (Huntsville)	(IE & Operations Research)
Ph.D. (1971)	Virginia Polytechnic Institute & State Univ.	(IE & Operations Research)
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AB (1943)	Fresno State College	(Geology)
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Clark, W. O.		
BS (1960)	Univ. of Kansas	(EE)
MS (1961)	Univ. of Kansas	(EE)
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BS (1958)	Univ. of Oklahoma	(IE)
MS (1959)	Oklahoma State Univ.	(IE)
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BS (1947)	Case Institute of Technology	(ME)
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Gonzalez, R. C.		
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ME (1967)	Univ. of Florida	(EE)
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BS (1965)	Purdue Univ.	(IE)
MS (1966)	Purdue Univ.	(IE)
Ph.D. (1971)	Purdue Univ.	(IE)
Meyer, T. A.		
AB (1938)	Univ. of Alabama	(Chemistry)
MS (1942)	Auburn Univ.	(Soil Chemistry)
Ph.D. (1949)	Ohio State Univ.	(Agronomy)
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BS (1961)	Long Island Univ.	(Ind. Mgt.)
MS (1965)	Polytechnic Institute Brooklyn	(Ind. Mgt.)
Ph.D. (1971)	Univ. of North Carolina	(Bus. Adm.)
Skinner, C. W.		
BA (1958)	Univ. of Texas (Austin)	(Math)
MA (1966)	Univ. of Texas (Austin)	(Math)
Ph.D. (1970)	Univ. of Texas (Austin)	(Computer Science)
Talavage, J. J.		
BS (1961)	Univ. of Cincinnati	(EE)
MS (1963)	Univ. of Pennsylvania	(EE)
Ph.D. (1968)	Case Western Reserve	(Systems)

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Ph.D.	(1963)	Oklahoma State Univ. (ME)
LLB	(1969)	Jones Law School
Hamby, H. G.		
BS	(1950)	Univ. of Georgia (Phys)
MS	(1961)	Univ. of Georgia (Phys)
Lueg, R. E.		
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MS	(1956)	Univ. of Texas (Austin) (EE)
Ph.D.	(1961)	Univ. of Texas (Austin) (EE)

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O'Brien, J. Fred, Jr.		
BS	(1957)	Auburn Univ. (ME)
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CONSULTANT

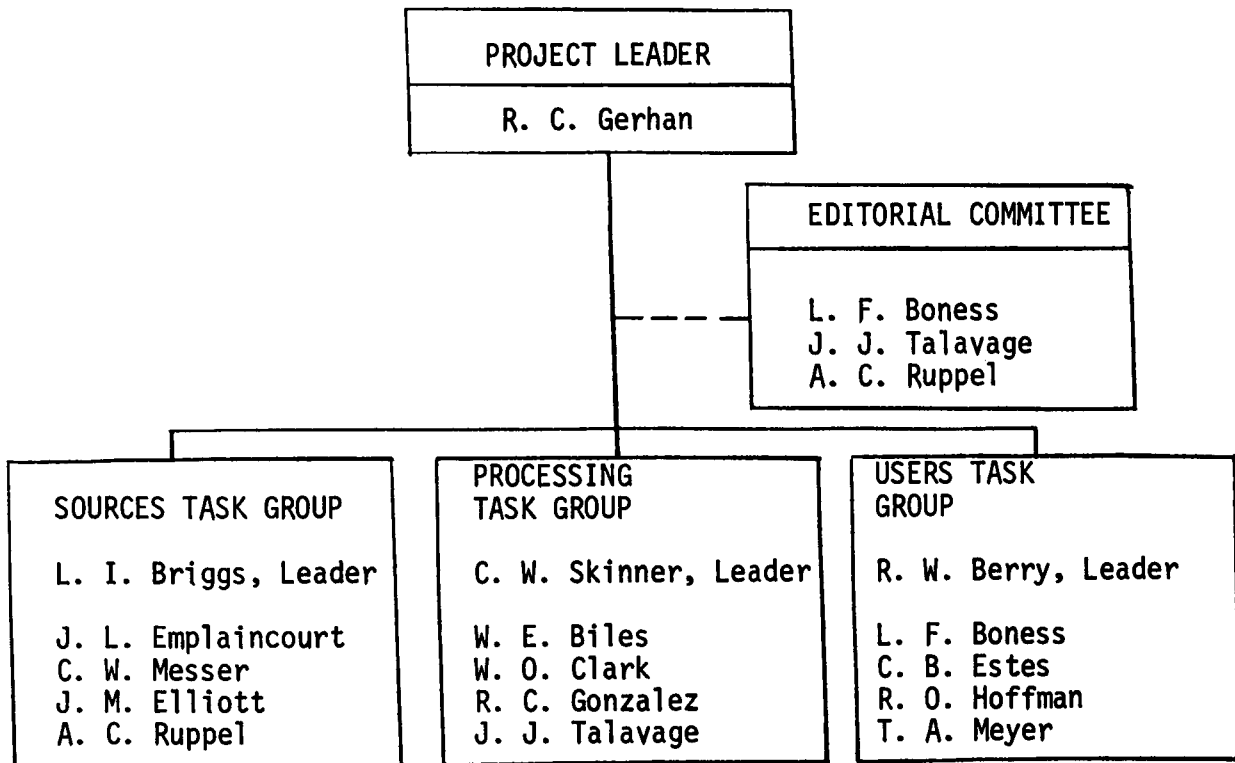
Cox, J. E.		
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MS	(1960)	Southern Methodist Univ. (ME)
Ph.D.	(1963)	Oklahoma State Univ. (ME)

APPENDIX E-2

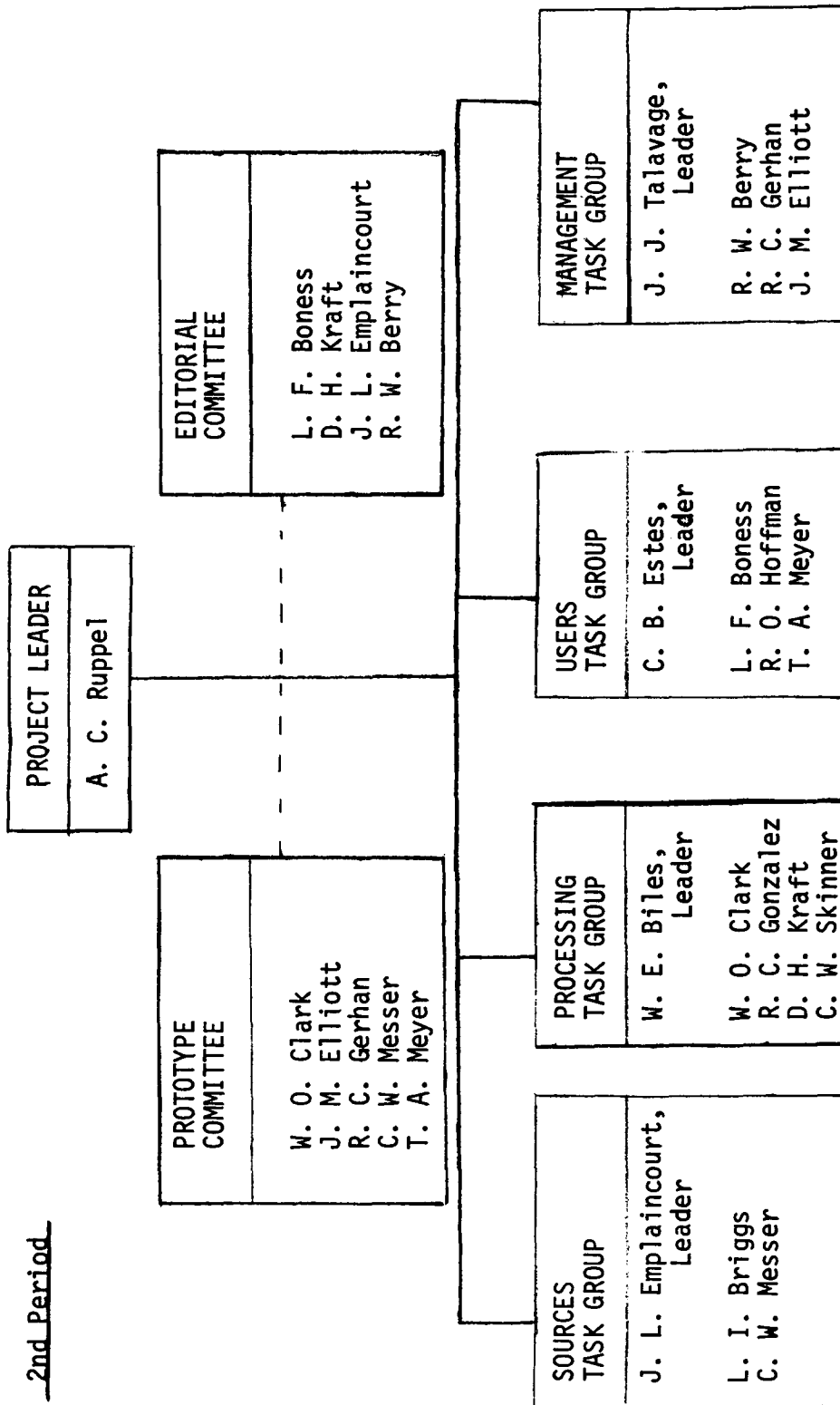
1972 AUBURN DESIGN PROGRAM ORGANIZATIONAL STRUCTURE

STAFF	
R. I. Vachon	Director
H. G. Hamby	Co-Director
R. E. Lueg	Associate Director
J. F. O'Brien	Administrative Director
J. E. Cox	Consultant

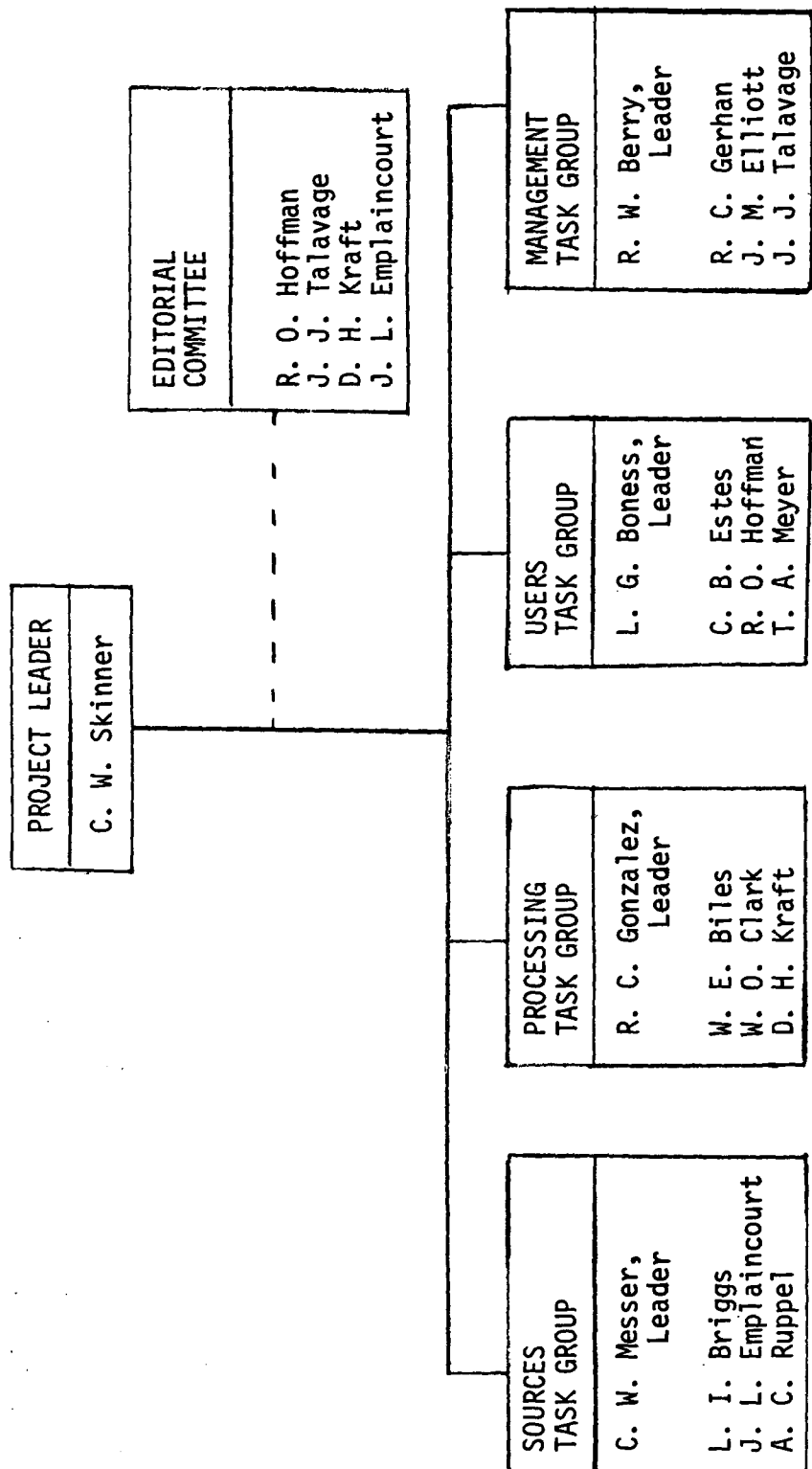
1st Period



2nd Period



3rd Period



APPENDIX F-1

GUEST SPEAKERS AND CONSULTANTS

LEGISLATIVE BRANCH

The Honorable Phil Smith
Representative 20th District
Talladega, Alabama

MARSHALL SPACE FLIGHT CENTER

Dr. Eberhard F. M. Rees
Director

Dr. George McDonough
Environmental Applications
Office

Mr. Charles T. Paludan
Environmental Applications
Office

Mrs. Charlotte Dabbs
Librarian

Mr. Marion Kent
University Affairs

Mr. Douglas Thomas
Computation Center

Dr. Robert Seitz
Computation Center

Mr. Robert Cummings
Flight Data Statistics Office

Mrs. Jane Bentley
Librarian

Dr. George Bucher
Deputy Associate Director for
Science

Mrs. Cleo Cason
Librarian

Mrs. Lois Robertson
Librarian

NASA HEADQUARTERS

Dr. Dudley McConnell
Director, Scientific and
Technical Information Office

Mr. Bernard T. Nolan
Head Earth Resources Remote
Sensing Airplane Program

Dr. Frank Hansing
Director, Office of University
Affairs

TENNESSEE VALLEY AUTHORITY

Mr. Al Stevens
Maps and Surveys Branch

Mr. Roger Betson
Hydrologist

Mr. Al Foster
Forestry

Mr. Wesley Smith
Agriculturist

ALABAMA DEVELOPMENT OFFICE

Mr. Edwin Hudspeth
Office of State Planning

Mr. Kent Anderson
Office of State Planning

Mr. James Lunsford
Office of State Planning

UNIVERSITIES

Dr. Ken Johnson
University of Alabama -
Huntsville

Dr. Bernie J. Schroen
University of Alabama -
Huntsville

Dr. Harold Henry
University of Alabama

Dr. Firouz Shahroki
University of Tennessee
Space Institute

Dr. Jack Belzer
University of Pittsburgh

Dr. James R. Anderson
University of Florida

MISSISSIPPI TEST FACILITY

Mr. Jack Balch
Director

Mr. Henry Auter
Deputy Director

Mr. Sid Whitley
Chief, Data Acquisition

Mr. Ian Miller
Director, Gulf Universities
Research Consortium

Mr. Roy S. Estess

STATE OF GEORGIA AGENCIES

Mr. Paul Pritchard
Office of Planning and Research

Mr. Richard Jones
Earth and Water

Mr. Martin Soffer
Department of Trade and
Industry

Mr. M. M. Alexander, Jr.
Department of Transportation

Mr. Ben R. Maxwell
Department of Transportation

Mr. Robert C. Moore
Department of Transportation

Mr. George Rogers
Department of Industry
and Trade

Mr. Ken Johnson
Department of Planning and
Budget

Mr. Nick Bonsanque
Office of Regional Planning

Mr. Bob Friedman
Department of Natural
Resources

Mr. Brit Williams
Department of Administrative
Services

Mr. John Hammond
Forestry Commission

Mr. Robin Jackson
Office of Planning and
Research

COOPERATIVE EXTENSION -
AUBURN UNIVERSITY

Mr. Ralph R. Jones
Director

Dr. W. H. Taylor
Associate Director

Dr. A. R. Cavendar
Chairman, Resource Use
Division

Dr. J. W. Gossett
Chairman, Animal Science
Division

Dr. T. B. Hagler
Chairman, Plant Science
Division

Dr. W. Lanier
Chairman, Environmental Health
Division

Dr. R. J. Ledbetter
Entomologist

INDUSTRY

Dr. Bruno Sables
GEOCOM, Inc.

Dr. Dennis Bond
Computer Sciences Corporation

Mr. Bill Wilson
UNIVAC

Mr. C. D. Jackson
IBM Corporation

Mr. Bob Gordon
IBM Corporation

Dr. Bruce Bachofer
General Electric Company

Mr. Buzz Ordonio
General Electric Company

KENNEDY SPACE CENTER

Mrs. May Stover
MSFC Residence Office

MANNED SPACECRAFT CENTER

Dr. Anthony J. Calio
Director, Science and
Applications

Mr. Charles Beers
Flight Control Division

Mr. Garner Kimball
Flight Support Division

Dr. John Dornbach
Applications Office, S&A

Mr. John Zarcaro
Earth Resources Program

Mrs. Barbara Eande
University Affairs Office

U. S. GEOLOGICAL SURVEY

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Assistant Deputy Director

Dr. Olaf Kays
Information Specialist

Dr. Avery Drake, Jr.
Geologist

Mr. Raymond Fary
Geologist

Mr. J. R. Balsley
Assistant Director-Research

Mr. A. F. Pendleton
Geologist

Mr. J. D. McLaurin
Geologist

OTHER GOVERNMENT AGENCIES

Dr. Jack Posner
National Aeronautics and
Space Council

Dr. Thomas J. Joiner
Geological Survey of Alabama

Dr. Gary North
U. S. Department of Interior

Dr. Charles Wende
National Space Science Data
Center

Dr. C. Everett Brett
Marine Environmental Sciences
Consortium

Mr. Ernest Todd
U. S. Department of Agriculture

Dr. Fred Haas
U. S. Department of Interior

Dr. Charles Weiss
World Bank

Mr. Norman Olson
Geological Survey of South
Carolina

Mr. Stuart Pyle
Water Resources Council

Mr. Tilden Curry
Tennessee State Planning
Office

Mr. Niles Schoening
Tennessee State Planning
Office

Dr. Jerry Ulrikson
Oak Ridge National Laboratories

Mr. Don Malone
Tennessee Valley Authority

Mr. Steve Webber
Tennessee Valley Authority

Dr. Larry Doyle
Alabama Geological Survey

Mr. Gilbert A. Penny
Army Missile Command

Mr. Roland Guard
Army Missile Command

Mr. Lawrence Taylor
E.D.A., San Diego, Calif.

APPENDIX F-2. SUMMARY OF SPEAKER'S SEMINARS

The successful result of the effort that is undertaken by the faculty fellows is largely dependent upon the input of speakers who are invited to address the group of faculty. Because conclusions given in ERISTAR are based on contributions of many invited speakers, it is desirable that a summary of their individual comments and opinions be recorded. The essence of each speaker's presentation as recorded and interpreted by the faculty fellows is presented here. No attempt is made to quote the speaker and in some instances the opinions and/or biases of the fellows are an integral part of the summary. The summaries are arranged in chronological order.

MANAGEMENT OF EARTH OBSERVATION DATA

Jack Posner
Space Assistant
National Aeronautics and Space Council
New Executive Office Building
Washington, D. C. 20502

Dr. Posner initiated his presentation by describing the origins of NASA's Office of Application, its objectives, and its proposed organization. The most important idea that came out of his early comments was that the Office of Applications is responsible for transferring the benefits of technology from the space programs to the public and private sectors. This function includes a responsibility for managing earth observation data. In later discussion, Dr. Posner described the Lead Center concept under which the Office of Applications expects to operate.

Perhaps more pertinent to our project was Dr. Posner's review of NASA's earth observation programs, the most immediate of which are ERTS-A and B. ERTS-A is scheduled for launch in July, with ERTS-B to follow about eighteen months later. There are 306 approved users of ERTS-A observation data in almost one hundred foreign countries. Dr. Posner also described several communications programs with which the Office of Applications is involved.

An interesting segment of Dr. Posner's presentation was the illustration of some of the capabilities of satellite observation and detection devices. Important in this phase of the talk was the point that space observation data must be correlated to actual conditions on the surface, called "ground truth".

USE OF EARTH RESOURCES DATA

Thomas J. Joiner
Assistant State Geologist
P. O. Drawer 0
University, Alabama 35486

Dr. Joiner has had experience in two areas of significance to our study group. The first area is in the use of NASA generated information (Apollo-9 and Imagery). The second area is in the location and "education" of potential users of remotely sensed earth resources data.

This experience revealed two facets of the problem which cannot be ignored:

1. The need to correlate ERTS data and ground truth (user verification of the observations).
2. The need to educate the users so that they are ready for the information that is on the way.

With reference to point one above, the ground truth can be obtained from:

- a. New visitations to sites determined to be of interest, and
- b. Current files maintained on a manual basis by various agencies. These files include Geological Surveys, Land Use Files, Water Quality Data, Maps, etc.

The problem: the current manual files are not easy to use and are inaccessible for many users. In addition, files are neither in standardized nor machine readable format.

The second problem discussed by Dr. Joiner concerned the users' readiness for new information. User Symposia held in Tuscaloosa and Mobile in 1971 indicated a general lack of knowledge, interest or enthusiasm (an interpretation of the results of a questionnaire distributed to the participants). The solution lies in education of potential users. This probably can be accomplished best by providing concrete examples of practical usage thereby overcoming a reluctance to "buy a pig in a poke".

Dr. Joiner has submitted a proposal for a project to assist volunteer users in the application of ERTS-A data to solve their problems. If the project is funded and attains its objectives, it should increase the demand for output from ERTS-B and subsequent programs.

THE ALABAMA DEVELOPMENT OFFICE

Edwin G. Hudspeth, Chief
Special Studies Division
Office of State Planning
State Office Building
Montgomery, Alabama 36104

The Alabama Development Office (ADO) was created in October, 1969, to plan for the comprehensive development of the State's human, economic and physical resources. It has three major divisions - Industrial Development, Office of State Planning, and State-Federal Programs. Mr. Hudspeth's responsibilities lie in the Office of State Planning.

Planning under consideration include community development, future land use, land use analysis, and community assistance in receiving low cost Federal insurance for flood-prone areas. The principal activity of ADO at the present time, however, concerns development of a water and related land resources plan in response to the guidelines established by the Federal Environmental Protection Agency.

A Water Resources Advisory Committee, with representatives from the Geological Survey of Alabama, the universities of Auburn and Alabama, the Environmental Studies Center, UAH (see summary report on talk by Ken Johnson), the Alabama Water Improvement Commission, and the Department of Conservation, was established to assist ADO in water and land resource planning and development.

The Alabama Water Improvement Commission is the responsible State agency for pollution abatement. Together with ADO it is developing plans for seven major metropolitan areas and fourteen river basins in the State.

Several air or water resource data storage and retrieval systems, developed by agencies of the Federal government, are available to State agencies:

STORET - a water data system developed by the Environmental Protection Agency (EPA) which provides service free to users.

SORAD - an air quality data system developed by EPA for State use.

MIAD - a soil classification mapping system developed by the Soil Conservation Service.

In addition, there are available software (COBOL) programs for querying files on Federal projects and reports. (FACS, FIX, and FAIR).

In reference to the ERTS project, the Alabama Development Office should be the link to users of the data in State government. The purpose could be to provide the means to make potential users aware of the data and its use potential.

INFORMATION NEEDS AND MANAGEMENT

Ken E. Johnson
Associate Director
Center for Environmental Studies
University of Alabama - Huntsville
Huntsville, Alabama

After mentioning the objectives of the Center for Environmental Studies Dr. Johnson discussed some current projects. Not only are they collecting data now on air and water pollutants but they are abreast of the state-of-the-art on environmental techniques. He referred to their part in the Metro-Huntsville water plan and its relationship to the Tennessee River Basin Plan and emphasized the management of water quality as a part of this plan. He noted the competitive position of the Center with the resources of Huntsville and the University at their service.

Dr. Johnson's colleague, Dr. Barnie J. Schroen, spoke about an Information System for Air Pollution Control Project. The system is currently being implemented to assist the Air Pollution Control Committee (APCC) in handling air pollution data. The approach is to utilize guidelines defined by the Environmental Protection Agency (EPA).

A detailed presentation of enforcement provisions was made. The system was designed by EPA for state and local governments and its function is to control enforcement activities, particularly those associated with permit and complaint bookkeeping. It is being implemented in COBOL with standardized inputs and various report-generation output capabilities.

Dynamic data is inputted on ACTION cards and the file is updated so that future reports will be current.

Also a "MINI" SAROAD (Storage and Retrieval of Atmospheric Data) was described. An EPA design, its function is to store and retrieve pollutant and meteorological data from sampling stations. It is to be compatible with SAROAD and implemented in COBOL and FORTRAN. Sampling stations were identified and data described.

EARTH RESOURCES OBSERVATION SYSTEMS

Gary North, Chief
EROS Experiments and Evaluation Office
MTF
Bay St. Louis, Mississippi 39520

The Earth Resources Observation Systems (EROS) is a Department of the Interior program designed for utilization of space acquired data for natural and human resources management. This program was initially established in 1966 under Mr. Udall. Today EROS is housed in the director's office of the United States Geological Survey.

Mr. North, a remote sensing specialist, presented various applications of space acquired data to a multitude of disciplines. He elaborated on the possibilities and potentials of data acquired by (1) satellites and (2) high altitude aircraft (such as U-2 and RB 57). Data collected by satellite could be applied to agriculture (crop diseases), forestry (forest fires), geology (discoveries of new minerals), geography (supplement and improve existing maps), hydrology (drainage basin characteristics - snow and ice depth measurements), marine resources (fisheries), wildlife (main question raised at an international convention on Earth Resources), and urban planning (such as Dallas and Fort Worth spatial growth).

The advantages of earth orbital sensing devices are as follows: (1) reduce data bulk, (2) reduce cost of data acquisition (one satellite photograph may replace 3200 conventional air photos), (3) provide data on a global basis, (4) increases applicability of automatic systems and (5) increases multiplicity of use.

To date, the work of EROS has been accomplished basically by aircraft and has been focused on developing the ability to interpret remotely sensed data. This is leading to the use and interpretation of data to be provided by ERTS-A (Earth Resources Technology Satellite), which is to be launched in July.

According to a survey made by the Department of Interior, the anticipated annual demand for satellite images is 20 million prints with the percentages of requests categorized by users as follows:

State govts:	9.5%
Local govts:	10.6%
Foreign govts:	0.7%
International and other Federal agencies:	4.2%
Commercial:	75.0%

When the EROS project was announced, a decision was made to store EROS data at Sioux Falls, South Dakota. The \$5 million building is presently under construction and all photo frames are being transferred to that location. Mr. North concluded his presentation with a description of the Mississippi Test Facilities.

THE ENVIRONMENTAL APPLICATIONS OFFICE, MSFC

George McDonough, Director
Environmental Applications Office
Marshall Space Flight Center, Alabama 35812

Dr. McDonough indicated that the Environmental Applications Office is organizationally under the directorate of Science and Engineering, where it performs a staff function, drawing from the expertise of the affiliated laboratories to work on identified problems. Additionally, university talent and the user himself are considered desirable resource sources, and work closely with the staff.

The office has conducted training programs in the areas of:

1. Multispectral Photographic Interpretation
2. Pollution Control
3. Fundamentals of Earth Resources
4. Fundamentals of Remote Sensing

Emphasis of the office is directed towards development in three areas:

1. The user as a partner.
2. The concepts of information management.
3. Specific disciplines.

The following is a list of characteristics which would tend to make a project desirable to the mission of the office, and as such, serve to indicate insight into the selection criteria:

1. Task should be feasible with existing (available) manpower.
2. Anticipated results should be of benefit to the public.
3. Task should enjoy a favorable cost-benefit ratio.
4. Task should develop favorable user relationships.
5. Task has potential feedback into NASA.
6. Task provides favorable publicity.
7. Task requires user contribution.

Dr. McDonough then gave a typical list of projects for demonstrative purposes:

1. Hydrological Parameter Determination
2. Land Use Survey
3. Agricultural Stress Detection
4. New Community Site
5. Pollution Monitoring
6. Urban Transportation Studies
7. Urban Environmental Quality

He then reviewed two projects in detail. These projects were the planning for a new community near Birmingham in a reclaimed coal mine area and the transportation analysis of the City of New Orleans.

Of importance to the Auburn Design Group was the realization that Earth Resources Data is not limited to data from space. Space data is

only a subset of a larger collection. Remotely sensed data should interface with other pertinent data in a data bank before being disseminated directly to users and decision-makers. The design of a system to accomplish this may well be the mission of our group.

THE UNIVERSITY OF ALABAMA ERTS PROGRAM

Harold R. Henry, Head
Department of Civil and Mineral Engineering
University of Alabama
University, Alabama 35486

Dr. Henry pointed out the critical need for an Earth Resources Information Management System. The system is a necessary tool for decision making.

He discussed the following papers in detail:

- (1) Harold R. Henry, Use of Data from Space for Earth Resources Exploration and Management in Alabama
- (2) Harold R. Henry, A Joint Project to Study the Feasibility of Applying Remotely Sensed Data in the Management of Natural Resources and the Improvement of Environmental Quality in Alabama

The construction and operation of the ERTS-A Satellite was discussed briefly by the speaker. For more detailed information on the construction and operation of the satellite refer to the following excellent publication:

General Electric Corporation, User's Manual Earth Resources Technology Satellite

Dr. Henry has received simulated ERTS-A data from Goddard Space Flight Center, Greenbelt, Maryland and hopes to have actual ERTS data shortly after the launch in July.

REMOTE SENSING

Charles Ted Paludan, Deputy Director
Environmental Applications Office
Marshall Space Flight Center, Alabama 35812

Mr. Paludan discussed details of his office and how it relates to our program. Emphasis was again placed on the USER aspects of the information problem.

It was pointed out that several demonstration projects have been initiated in order to demonstrate MSFC capabilities. These include Urban

Environment, Land Use Studies and Techniques, Hydrology, and Data Management and Interpretation. Other projects deal with Geology and Forestry.

The Urban and Land Use programs were discussed in some detail. In connection with the Urban program, he mentioned a community renewal program presently being implemented in the city of Denver, Colorado. It was pointed out that a data base is needed for programs of this type.

With regard to the Land Use program, it was mentioned that NASA and TVA are cooperating in a land-use mapping project. He mentioned world-wide projects related to land-use management and, in particular, discussed the Great Britain program. This particular program employed 4000 people and took eight years to complete. Multi-spectral photography was suggested as an alternate route to the same goal, but with obvious savings in time and dollars. This technique was also suggested for crop disease detection.

The talk was concluded with a demonstration of the photographic and imagery facilities at MSFC.

THE STATE CLEARINGHOUSE

Kent Anderson and
James Lunsford
Office of State Planning, ADO
State Office Building
Montgomery, Alabama 36104

The purpose of the State Clearinghouse of the Alabama Development Office is to establish a project notification and review system to:

1. coordinate the federal development projects
2. coordinate state plans
3. coordinate planning in multijurisdictional areas
4. coordinate environmental impact statements

Any request for federal aid must be sent to the State Clearinghouse. They process approximately 600 projects per year with a total federal aid request value of about 520 million dollars.

Within five days of receiving a planning document the sendee is notified that it is being processed. A form letter and a copy of the planning document is sent to any agency which may be affected by the plan. Comments are returned to the State Clearinghouse which recommends funding, does not recommend funding or acts as a mediator for any problems that develop between agencies. Within thirty days the State Clearinghouse notifies the sendee of the status of the planning document.

The State Clearinghouse also publishes various bibliographies and instruction manuals to help develop planning documents. They are using several computer programs to assist in keeping track of applications for federal aid.

THE NATIONAL SPACE SCIENCE DATA CENTER

Charles Wende
National Space Science Data Center, GSFC
Greenbelt, Maryland

The National Space Science Data Center (NSSDC) was established by NASA to provide practicable use of reduced data from space science investigations including an active repository for such data. As such, it is responsible for the active collection, organization, storage, retrieval, announcement, dissemination and exchange of scientific raw data obtained from spacecraft experiments.

Dr. Wende stated that NSSDC acquires reduced data records usually prepared by a compaction, editing, and merging operation that is performed by the principal investigator. NSSDC assigns a specialist in the appropriate discipline to arrange for data acquisition. The Data Center identifies, verifies, labels, and documents the data. The final analyzed data is accepted in machine-sensible form and nonmachine-sensible form.

Data announcements for users are made through the Data Catalog of Satellite Experiments which lists the NSSDC collection of data.

NSSDC provides the Data User's Note, a document which describes the data available at the Data Center with pertinent bibliographic material. Also, a Data Set Package(s) which is a handbook or users guide is available.

NSSDC stores information as:

- (1) Technical Reference File -- TRF
 - a) subject
 - b) key word identification
- (2) Spacecraft
 - a) ID 67 (year) - 070A (serial number)
 - b) Experiments 67-070A-01 (experiment number)
 - c) Data 67-070A-01A (data code)
- (3) Automated Internal Management -- AIM
NSSDC internal code
- (4) RASH -- Request And Status History
Requestors -- who ordered what, how many, etc.
- (5) DIST - Distribution list

NSSDC does not work on operational day-to-day data. NSSDC mostly serves the space scientists.

NSSDC serves about 2000 requests a year.

THE SYSTEMS APPROACH AND GURC

Bruno E. Sabel
GEOCOM, Inc.
2122 Governor's Circle
P. O. Box 94049
Houston, Texas 77018

Dr. Sables is former director of GURC (Gulf Universities Research Consortium), and is now a consultant in the earth resources area.

He emphasized the importance of not prejudging solutions in order to maintain the effectiveness of the system approach.

Part of the Apollo mission was to find out what the "information space" of the moon was. As a contribution, NASA formulated 50 basic questions about the moon. JPL translated these into sub-questions and possible methods for answering them -- the result, a "spaghetti" chart. Conclusion -- get answers to any 10 of the 50 and you get the answers to the others automatically. Scotland Yard tried to use the systems approach in solving a crime but it failed because of initial overspecification of the objective.

Some background on MTF was given. An emerging consideration is that there is considerable overlap in the research effort; i.e., various agencies are tackling the same problems. The potential for considerable savings exists. A research program for the Gulf area was formulated by GURC over a 5 year period, but not funded. Dr. Sables feels the turn-down was due to a lack of a systems perspective on the part of the GURC proposal reviewers.

He reviewed the efforts to evaluate national data management systems; e.g., one by INFORMATICS for the Navy. Two types were noted:
(1) a storage and retrieval type -- glorified filing system,
(2) decision systems -- they give you back more than you put in.

Consider storing information, not data; i.e., try to think of how one can avoid storing data. How do we eliminate redundant, unnecessary data in data reduction for a particular purpose. Imagery can be an effective storage medium.

Systems, to be manageable, should be closed.

When an experiment yields inconclusive results, the experimenter should consider whether or not the right question has been asked.

The State of Louisiana is seeking to have the Sleidell Computer Center at MTF provide a decision system with regard to environmental questions. The Louisiana legislature now uses CRT's in information retrieval.

System output must be meaningful and be effectively displayed even to unsophisticated users.

Advice on selecting systems approach team members: don't pick people with tunnel vision and thinking.

ENVIR (a modification of TAXIR), now known as INFORM, is a scheme for environmental data management. Steps in data management and steps in data systems evaluation: (1) definition, (2) data methods, (3) user projects, (4) test case runs, (5) assessment of total data need, (6) report.

Task 3 Report of GURC Project covered user projects. Two test cases were: (1) the Mississippi Pond, (2) Escambia Bay. The latter involved the legal and economic aspects of biological and chemical data. (Contact Barry Lessinger of the Florida Coastal Coordinating Council in Tallahassee regarding a data base for environmental control. Also check with Doug Wilsey with TRW-Washington). The data buoy program also served as a test case.

The improvements realized in seismic data gathering and analysis should be applicable to geothermal exploration, and similarly with remote sensor technology. The systems approach can help to convert interesting heat anomalies into a competitive energy resource.

Ways to cope with the "wrong" question being asked of your system: (1) build an infinite question space -- OK, how? (2) use "subtle" devices to constrain the questioner's format; e.g., the light pen on a CRT, (3) store data in an integrable format.

A system can incorporate a self-purging feature based on activity measures.

Man's "turn-around time" in situations requiring a hyper-rapid decision is too low; thus faith may have to be placed in the machine.

GURC had a matrix organization with disciplines as the columns and problem/ functional aspects as the rows. Dr. Sables termed this his rug organization.

The analysis of existing data "masses" can yield significant inductive insight and thereby create a basis for a stronger systems analysis.

USGS has examined national data banks and has developed a scheme for tapping them. (Contact Ray Wallace at MTF). The INFORMATICS report for the Navy attempted to rate systems (Call Wallace Brown at MTF).

The best system for managing earth resources data does exist; in fact there are several; e.g., TRW's GIM. The key is how much modification effort can be applied to tailor it to actual needs.

LIBRARY SYSTEMS

Charlotte Dabbs
Librarian
Marshall Space Flight Center, Alabama 35812

Mrs. Dabbs distributed microfiche copies of a number of reports dealing with information retrieval. She pointed out some advantages of microfiche over full size printed copy and encouraged members of the group to make use of the microfiche reader/printer located in our spaces. Two of the advantages are:

- o economy of storage - the equivalent of a file cabinet full of documents can be stored in a shoebox
- o economy of reproduction - a report may be reproduced for a small fraction of the cost

Two disadvantages are:

- o poor readability compared to printed page
- o hard copy of rather poor quality and relatively expensive

The NASA information program is a system for storage and distribution of documents deemed to be of interest to the aerospace community. Two indexes are published which list documents coming into the system.

- o Scientific and Technical Aerospace Reports (STAR)
- o International Aerospace Abstracts (IAA)

Documents are listed by subject using index terms which have been drawn from the NASA Thesaurus. The thesaurus is open-ended, continually growing as new subjects become important. However, when a new term is added to the thesaurus, older reports are not re-indexed using the term.

The "NASA tapes" contain, in machine-readable form, sets of index terms for all documents which have been placed in the system. There are nine million postings on the tapes. One system for performing searches on this file is the RECON system, an interactive time-shared system which is operated on a computer at College Park, Maryland, and interfaces with the user through a CRT typewriter with attached printer.

A current awareness program called Selective Dissemination of Information (SDI) was installed at MSFC for a while but was dropped because it was too expensive. A user profile consisting of a boolean combination of index terms was developed for each user. Then each week the user was informed of all new documents in the NASA system which matched his profile. The system worked well but it was sometimes difficult to develop a profile using index terms available. An example was the theoretical physicist who received a list of 600 citations because his profile was too general. The successor to the SDI program was the current NASA/SCAN system in which a user selects one of a number of standard profiles. NASA employees and anyone who has a NASA contract may make use of the SCAN system.

NASA's EARTH RESOURCES INFORMATION SYSTEM

Dudley McDonnell, Director
Scientific and Technical Information Office
Office of Industry Affairs and Technology Utilization
NASA
Washington, D. C. 20546

NASA's Earth Resources Information System is in process of development under the Interagency Coordinating Committee Earth Resources Survey Program (ICCERSP) with Dr. Homer Newell, chairman and Dave Williamson, deputy (Code AAA, NASA Headquarters, Washington, D. C., 20546).

The purpose of the program/system is to manage information and data from: (1) ERTS, (2) EREP (Skylab) and (3) Aircraft programs. As part of policy, the "program will include cost/benefit assessment ... information program to include cost recovery data and information in public domain prior to any other use."

Objectives of the program are: (1) integration of imagery, non-imagery data, and reports (2) broad public announcements and availability of data and reports, and (3) communication and feedback among program participants.

The problem of equal access to data vis-a-vis equal ability to interpret data was discussed. NASA chose to release data immediately to everyone with the constraint that an agency or business cannot use the data for profit until analytical techniques and interpretations of the data are also released to public domain. The alternative of holding all data back until processed and examined was rejected.

The process of dissemination of information was dictated by the federal requirement of availability of information. This would be accomplished primarily through information dispensing services of existing federal government agencies. Data and information will be free to government agencies and other groups directly related to government agencies. Private users will assume printing and mailing expenses.

In summary, Dr. McDonnell listed the following design features of the program:

- (1) Rapid and convenient public availability
- (2) Accessibility and retrieval of data and document citations through remote terminals
- (3) Controlled distribution of reports and bibliographies to program participants
- (4) Selective dissemination of announcements
- (5) Public availability of catalogues and indexes
- (6) Utilize available public agency information distribution systems
- (7) Program-wide feedback for evaluation

Raw data will go to Goddard for processing. Information will be stored at Goddard and Sioux Falls. Dr. McDonnell implied that eventually the whole system may be turned over to Sioux Falls facility which is under the jurisdiction of the Department of the Interior.

THE MARINE ENVIRONMENTAL SCIENCES CONSORTIUM

C. Everett Brett, Coordinator
Alabama Marine Environmental Sciences Consortium
University, Alabama 35486

Dr. Brett discussed the History of Marine Science Programs in the State of Alabama, noting in particular the creation of the Marine Science Institute at the University of Alabama in Tuscaloosa in 1967. In 1969-70 the Marine Environmental Sciences Consortium was established with seventeen (17) four-year institutions participating in the Program. The administrative and policy-making structure of the Consortium was also discussed.

With respect to the "Earth Resources Information Problem", Dr. Brett sees the Consortium as a consulting organization to identify problem areas and advise the State Government on various related to Marine Science and Coastal Zone Management. He has proposed that a Marine Resources Commission be established to interface between Government and the Consortium.

Dr. Brett is co-investigator in the University of Alabama ERTS-A Project.

GOVERNMENT ORGANIZATION, STATE OF ALABAMA

Phil Smith
Representative 20th District
House, State of Alabama
P. O. Box 15
Talladega, Alabama

Organizationally speaking, state government in Alabama at all levels is weak. City governments tend to be a "mayor figurehead" organization with the exception of a few of the larger cities which are responsible for administering some budgets. County governments, essentially without exception, are county commissioners whose only function is to gain roads for their county.

The state government is in three parts: Judicial, Executive, and Legislative. The Judicial branch is very modern and reform-minded. The Executive branch has no organization in the sense of Line and Staff functions. Instead, over 200 different bureaus, agencies, committees, etc. report directly to the governor. Although the governor personally divides and assigns budgets to each group, there is no real control over the activities of each group because of the lack of a business-like organization.

According to a recent study, the Legislative branch ranks 50th (worst) from the view of organization and tools that it has to work with. All leaders and committee chairmen are appointed by the governor and therefore all legislation is "pork barrel" legislation. The legislature meets for 36 days every other year as provided by the antiquated (1901) constitution and consequently legislators don't have time to read each of the proposed bills before them.

In conclusion, the state government is so poorly organized that no information system could help at this time. The nearest thing to a staff office and information system user is the Alabama Development Office whose primary function is to attract industry and obtain federal dollars for Alabama. Therefore, the most promising customers for an Earth Resources Information System are the Regional Council of Governments, of which Alabama has twelve.

IMAGE PROCESSING

Doug Thomas
MSFC Computer Laboratory
and
Dennis Bond
Computer Systems Division
Computer Science Corporation
Huntsville, Alabama

Mr. Thomas initiated the presentation by describing the hardware configuration for a planned image processing system. This system will use a PDP-9 on-line with an IBM 7094. The PDP-9 will serve as a communications link with the IBM 7094, which performs the image processing function. Mr. Thomas also indicated that mini-computers might eventually become the communications link in this system.

Dr. Bond then described the software and image processing algorithms for multi-spectral scanned data. He showed a block diagram for a 24-channel, multi-spectral scanner image processing system. The scanner registers the spectral radiance signatures of the various surface features. Then algorithms must be used to interpret these spectral signatures in "gray-image" form.

An important operation with 12 or 24-channel scanning systems is "feature selection". This means selecting the most significant features transmitted over 12 or 24 channels. Dr. Bond described procedures for pattern recognition, including one using a linear discriminant function. He then showed how this procedure could be applied to a crop classification scheme. He pointed out that the procedure must be carefully correlated with ground truth information. A disadvantage of the procedure is that it is difficult to apply it to widely different surface regions; e.g., crop land to urban area.

THE SOIL CONSERVATION SERVICE

Ernest Todd
Assistant State Conservationist
USDA
Auburn, Alabama 36830

The SCS is the technical arm of USDA - the action agency - the technical engineering part. The extension service (county agents) is the information agency. The chain of command is: Washington headquarters to Regional Conservationist to State Conservationist to Area Conservationist to District Conservationist. The District Conservationist deals with the individual landowner.

The SCS provides advisory services and planning. They lay out ponds, lagoons, do terracing and river basin surveys for state governments. The SCS deals with large acreage not individual lot size. They will assist the developer of a tract. Farmers usually seek out the SCS rather than vice versa.

MIADS (Map Information Assembly and Display System) is a computerized system that identifies soil type, ground cover, subsurface minerals, etc. on designated cells of two letter sizes (332 acres). SCS makes much use of aerial photos.

REMOTE SENSING COUNCIL FOR THE SOUTHEASTERN UNITED STATES

Firouz Shahrokhi
University of Tennessee Space Institute
Tullahoma, Tennessee 37388

Dr. Shahrokhi's presentation was essentially a chronological account of the formation of the "Remote Sensing Council for the Southeastern United States." It is a new organization with representatives from several governmental agencies and institutions of higher education - private enterprise has not and will not be encouraged to join the Council.

The objectives of the Council are six in number but can be summarized as "The promotion of the use of remotely sensed data." This prime objective will be attained by the following means:

1. Guide annual conference sponsored by UTSI.
2. Conduct educational seminars, short courses, etc.
3. Encourage research by identifying problem areas.

The Council was conceived as a result of activity which began in 1971 - Dr. Shahrokhi and J. Rhudy conducted a study and prepared a report under a NASA grant - "Remote Sensing Techniques in Evaluating Earth Resources - Study of Potential Users of Satellite and Aircraft for South Eastern Region of the United States" (August, 1971). Some of conclusions:

1. The user community must be identified, and educated with respect to the potential applications of remotely sensed data (Imagery).
2. The satellite generated photos may have less applicability than aircraft photographs - (Less flexible - an eighteen day cycle).

As a result of this study, Dr. Shahrokhi at the UTSI developed a one week short course and planned a regional conference. These activities were held in March 1972. Some interesting statistics are:

1. Forty people were enrolled in the five day - thirty-five hour short course.
2. 100 people attended the two day conference, including the authors of the fifty papers presented.

Conference participants concurred on the need for an organization such as the Remote Sensing Council.

The user community has not been sold on the benefits of this space-based technology. There must be a concerned marketing effort to:

1. Identify the customer (User)
2. Determine his needs and,
3. Produce a user-oriented output.

COST/BENEFIT ANALYSIS OF EARTH RESOURCES DATA

Fred Haas
U. S. Geological Survey, EROS Program
18th and F. Street, N. W.
Washington, D. C. 20550

Dr. Haas, with a background in Chemical Engineering and Management and Economics, gave an interesting and frank talk on the upcoming study to be done on the cost/benefit of the Earth Resources Observation System (EROS). He was a participant in a Langley/Old Dominion Engineering Design summer project, working on TRIAD, in 1969; and is also a professor at Virginia Commonwealth University (in Richmond). Dr. Haas, now with the U. S. Geological Survey, is the technical liaison officer for the three organizational combinations bidding on a \$1.5 million, thirty man-year, year-and-a-half contract to do the study. Much detail was presented as to the nature of the announcement, request for proposal, and grant award processes. The original request for proposal (RFP) was asked for and Dr. Haas promised to send it to us. The contract has not been awarded yet so some of these details are still sensitive. The study will be a complete study, incorporating some of the partial, incomplete cost/benefit studies done in the past.

Phase I, now going on, is a 60 day funded design and proposal of the study itself (Phase II). 45 companies bid initially, 18 given RFP's, 10 returned proposals, 3 working on Phase I now (to be completed July 24). The 3 groups are:

1. Willow Run Lab (U. of Mich.) & Mathematics & Systems Research Corp.
2. Earth Satellite & Booz Allen Applied Research
3. General Research Co. & North American Space Division (West Coast)

ERTS-A will begin sending data down as soon as it is launched. A group of 300 principal investigators, 100 foreign, have been supported in doing experiments based on the earth resources data. In return, they will be questioned as to the use and usefulness of the data.

Problem: how not to get in the PI's hair too much and yet get meaningful usage of the data. The names of the PI's are in the ERTS users manual. One example of a technique that might be used to analyze user benefits is the Delphi technique on a panel of users. ERTS-A presupposes the result of the cost/benefit study will help make decisions in the future and will use the ERTS-A user data.

Dr. Haas also gave a brief review of the technology involved in Earth Resources work. He pointed out that military classification poses severe constraints and that the resolution will be about 300 yards with some identification of smaller objects due to signature. ERTS is a compromise. ERTS-A, due to be launched in about a month, points out the potential, using available technology such as repetitive data (every 18 days). The satellite does have some storage capacity and can be queried. ERTS-B will be a backup for A, with possible additions if deemed desirable. More satellites may be coming, as well. The EROS data center, very user oriented, is in Sioux Falls, S. D. NASA is responsible for launch and for initial data collection and processing (NASA Goddard - NDPF). One point was made, users are to be served and must be identified. EROS plans to have a code of user agency, individual number, and geographical area.

The federal bureaucracy is just a group of people trying to do a job. Dr. Haas told us about the interagency coordinating committee trying to bring various interests together on the project. They review status reports and try to resolve difficulties. He also pointed out the learning curve effect; how long will it take for people to adopt new technologies? He felt that EROS must be upgraded so as to be able to push the use of the new technology.

Dr. Haas believes cartographers and land use surveyers will find ERTS data very useful. Other benefits will come up that have as much potential such as meteorology, pollution monitoring, and mineral exploitation. Economics, good sense, politics, and vested interests are all problems. An information system will be needed regardless of the success of ERTS. It must be designed properly.

Finally, he said that the U. S. Geological Survey wants to move forward. He urged us to help them move forward by really doing a good job on our report.

INFORMATION MANAGEMENT SYSTEMS

Jack Belzer, Professor
Knowledge Availability Systems Center
University of Pittsburgh
135 North Bellefield Street
Pittsburgh, Pennsylvania 15213

The University of Pittsburgh has several programs in information sciences. These programs started with the Graduate School of Library

and Information Science, which was later followed by the Knowledge Availability Systems Center (KASC). At the present time, they also have a Ph.D. program in information science. Besides directing the KASC program, Dr. Belzer is involved in the Industrial Engineering Department which is developing an Information Engineering Program.

KASC started as a regional dissemination center for NASA, and received tapes from NASA of all the literature that had been collected from sponsors. NASA established 6 of these centers throughout the country: (1) S. California, (2) University of New Mexico at Albuquerque, (3) Bloomington, Indiana (U of Ind.), (4) University of Conn., (5) Durham, N. E., (6) University of Pittsburg. The one at Pittsburg was a recently established with the NASA files and chemical abstracts (titles and digest). Each one of the centers have additional files.

Information is something people have been used to getting free "but they now should pay for what they get." KASC takes documents and someone reads and indexes them. They try to identify the literature that the user wants. "No matter what you give them, people are not going to get what they want. They want information--they are given something in which they think the information exists, then the people have to search for this information." The user does not get the document, he gets a bibliography and/or abstracts, he receives 2-3 times as much as he needs. The U. of Pittsburg has consultants, experts, and salesmen (usually faculty members from the School of Engineering).

Once the center knows what the user wants, an information specialist does a computer search, the output of which is simply accession numbers to abstracts. A stack of abstracts goes to the consultant, who sorts them out. Then finally, the user sorts them out himself to get what he wants. "A rather poor system" (Belzer). Ideally the user should interface directly with the system, therefore he could make his own selections as he proceeds (He knows what he wants). The problem is: Can we give the user the information instead of a pile of abstracts? Can we store something that is more meaningful than a list of references?

KASC does not only sell NASA & Chemical Literature, but also what other centers have. They have two kinds of services:

1. Retrospective
2. Current Awareness

The Current Awareness itself provides two types of services: (a) personalized (more expensive), (b) standard search (search an area of interest which many people have, and they have one package for several customers). Details on cost are available. Dr. Belzer also described his experiments with picturephones. (If they are developed properly, and if cost is kept down, they may be a step in the right direction.)

Also described was the S. D. 500 which can hold 49,000 microfiches (one microfiche can hold up to 190 pages for a total of 5 million document pages which represents a good size, specialized library). The S. D. 500 has 20 rotating shelves, and access to any fiche is possible within a maximum of 15 seconds.

PRINCIPLES OF INFORMATION MANAGEMENT

Bill Wilson
Data Processing Consultant, UNIVAC
Huntsville, Alabama 35802

Mr. Wilson opened his discussion with some sympathetic remarks about the scope of the earth resources information problem with which we are engaged. He specifically mentioned the multi-media and data disparity aspects. He concluded his remarks in this general area by suggesting that a "motley problem" deserves a "motley solution".

This was followed with a tutorial discussion on data structures as they relate to storing, retrieving and recording.

Discussion then turned to data base aspects. He referenced three documents:

1. A survey of generalized DBMS
2. Feature Analysis of generalized DBMS
3. Data Base Task Group Report (CODASYL).

These documents present the proposal for a Data Description Language (DDL) for describing a data base, a DDL for describing that part of the data base known to the program, and a Data Manipulation Language (DML). Use of this concept will require software for each computer configuration. A Data Management Routine (DMR) administers the interfaces. A DDL, operating through a software package creates an object scheme, sort of a way of organizing (structuring) the data base. A host language, through DML then provides the ability to interact with the data base in that DML is the language interface with the Data Base Management System (DBMS). (For more insight into this area, see reference 3, above).

Discussion then turned to the area of organizing of data bases. Certain tradeoff and selection criteria were mentioned at a general level. The session closed with comments on addressing files. Basically two ways exist, a directory procedure and an algorithmic procedure.

OVERVIEW OF NASA's AIRPLANE PROGRAM

Bernard Nolan, Head
Earth Resources Remote Sensing Airplane Program
NASA
400 Maryland Avenue, S. W.
Washington, D. C. 20546

Mr. Nolan presented a brief overview of remote sensing related to NASA's Aircraft Program.

Applications of the program were discussed by the speaker. They focused on the Florida Keys - geographical features; Dallas and Fort Worth, Texas - urban analysis; Imperial Valley - crop development; and Yungay, Peru - disaster research.

Aircraft used in the program and operational heights are as follows:

1. C47 - 10,000 feet
2. NP3A - 25,000 feet
3. NCB0B 35,000 feet
4. RB57F - 60,000 feet
5. U2 - +65,000 feet

The U2 aircraft is an excellent platform for remote sensing. It is able to fly a 6 hour mission, carry a 17,000 pound payload and uses only 500 feet of runway on take off. U2 aircraft are stationed at Moffet Field, California and Wallops Island Station, Virginia. RBV and multi-spectral scanner cameras have resolutions of 2-3 feet.

In the aircraft program, extensive work has been done on remote sensing of corn blight using RB57F aircraft. To determine the extent of damage large parts of Ohio, Indiana, Illinois, Iowa, Nebraska, Minnesota and Missouri were photographed every 2 weeks. LARS and LARSYS (Purdue University) were used to help analyze the extent of the damage.

Aircraft have been extremely helpful in analyzing disasters, i.e., flood conditions, including Rapid City, South Dakota and the Chesapeake Bay area.

The planes are presently mapping the entire state of Arizona. The final maps will be examined for many applications, including land use and tax revenue, (NASA, USDI and Arizona are jointly involved in the mapping survey).

NASA (Regional Centers) are active in aircraft programs. For example, NASA-Lewis Research Center has a small but expanding program. The center is focusing on pollution and ice flow problems of Lake Erie and some agricultural applications in the State of Ohio.

Earth observation satellites were discussed briefly. These satellites include ATS, SMS, TIROS, ITOS, NIMBUS, ERTS and SKYLAB.

The overall aircraft program is being reduced. It appears many of its functions will be taken over by ERTS A and B or similar satellites. Aircraft, however, will still be important as a remote sensing platform for repetitive or routine and emergency or disaster work.

COOPERATIVE EXTENSION SERVICE, AUBURN

Ralph R. Jones, Director
Cooperative Extension Service
Auburn University
Auburn, Alabama 36830

Attendees from Auburn Cooperative Extension Division were:

Dr. Ralph R. Jones, Director
Dr. W. H. Taylor, Associate Director
Dr. A. R. Cavendar, Resource Use
Dr. J. W. Gossett, Animal Science Division
Dr. T. B. Hagler, Plant Science
Dr. W. Lanier, Environmental Health
Dr. Ledbetter, Entomologist

Dr. Jones and associates mentioned the following facts.

- 1400 staff members
- 4 to 15 members in a county
- 67 counties have staff members
- the division has programs from youth work (4H) to resource development
- division users are homemakers, farmers, livestock raisers, agricultural companies, agricultural government agencies
- 15 to 20% of the population is reached per advertisement attempt
- the extension division would prefer to have earth resource data interpreted for them
- individual needs of the various disciplines were discussed.

They stressed that even though the ERTS data looks promising they want to be shown the results of the satellite and airplane data before being asked if they can use the data. In other words, a salesman type approach must be used by the pushers of Earth resources information if prospective users are to be convinced easily and quickly that this new technology is here to stay (assuming that the new technology is more attractive to use than the old way of doing business).

A LAND RESOURCES INFORMATION SYSTEM - DREAM OR REALITY?

James R. Anderson, Professor
Department of Geography
University of Florida
Gainesville, Florida 32601

Dr. Anderson gave an outline of a paper he has written, containing a summary of his thoughts about a land resources information system. He stressed the need for a system that is national in scope, pointing out that we are not there yet and that there is much hard work needed to get us there.

The amount of data in existence is growing at fantastic rates so that people are being inundated with data and information. Much of the data is unorganized and unused, giving rise to the potential for automation. One area of concern that generates a need for data is the environment. For example, legislators and planners will need a good deal of reliable information. Some of these specific concerns are agriculture, forestry, land use, and urban growth.

The data handling system must be inexpensive, flexible, highly capable of analyzing data, quick in response to requests for information, and quick about getting data absorbed and available from the many sources. Some of these sources are ground inventories and surveys, remote sensing (least understood) and combinations of several sources. Remote sensing may be best for remote, sparsely populated areas where it is hard to get people to go in and get ground data.

A system is needed that will yield the most useful data; data that is reliable and repeatable over time. It is hard to specify what this actually means due to the complexity of gathering land resources information over large geographical areas. Some factors to consider are variety, quality, accuracy and cost. A rational approach is needed to select data to be included in the system from consideration of management decisions to planning and research uses of data. Priorities are needed, to determine the urgency of each data need. For example, consider economic development, agriculture, forestry, under-used land, current land use, urban areas and environment. What priorities are there to determine the most crucial needs? Public concern is increasing and a national land use policy is in urgent need of being formulated.

The data can be structured as being relevant to micro-vegetation, surface geology or hydrology, topography, soil, and current land use areas. There are local, state, and national interests that must be balanced to eliminate, via planning, the data gaps caused by expense and lack of knowledge. We need uniformity, maximum detail, periodic grouping and summarization, and association of data to various applications. It is difficult to get effective information quickly owing to communication problems and time lags or lapses between acquisition and use. Guidelines needed for land use management are one example where this problem becomes clear.

Data are usually collected for specific purposes by various agencies, jealous of their own fiefdoms. Cooperation and coordination are needed. Specific uses should not be hampered, however. Definition and interpretation of data requirements must be made. Is centralization or fragmentation the way to get data to the appropriate user?

Another question is one of scale. A common basis of cell definition is needed. Yet, flexible capacity is also necessary. This calls for interagency cooperation. The scale of maps is usually too small for the users.

There is much planning and work to be done if the current chaos is to be organized. One main problem is geo-identification and land use. An example of the difficulties involved in coding of data and obtaining uniformity is poor land records.

Another difficulty lies in the classification of land resources which is by no means standardized or uniform. Such standardization is indeed desired. There may not be one ideal scheme for classification; moreover, there are vested interests that are affected by the classification scheme that is used. For example is chaparral forest or rangeland? It makes a difference if a state gets federal aid based on its acreage of forestland.

A final issue brought up by Dr. Anderson was that of one central information system versus several systems. What levels of coordination, duplication and uniformity are needed: User and hardware/software considerations must be taken into account.

The outline of the talk given by Dr. Anderson follows:

A LAND RESOURCES SYSTEM

- I. The Data Revolution
- II. Environmental Concerns and the Need for Data
- III. Some Responses to the Concerns About Land Resources and the Environment
- IV. Capabilities Needed in an Information System
- V. Approaches to Data Collection
- VI. Kinds of Data Needed
- VII. Organization of the Data Collection Process
- VIII. Scale of Generalization

IX. Geo Identification and Data Use

X. Time Lapse and Data Needs

XI. Standardization in Classification Procedures - The Example of Current Land Use

XII. Information System or Systems?

MSC PROGRAMS

Anthony J. Calio, Director
Science and Applications
Charles A. Beers, Technical Assistant
Flight Control Division
Garner Kimball
Flight Support Division
Manned Spacecraft Center
Houston, Texas 77058

During the course of their visit to MSC the faculty fellows obtained much useful information from Dr. Calio, Mr. Beers and Mr. Kimball. Dr. Calio talked about the MSC Aircraft Program and some of the successes and failures of past efforts. He mentioned the diversion of the RB57 to California just after the earthquake several months ago. MSC was above to provide the Los Angeles Police Department with photographs (with interpretations) of the devastated areas 24 hours later. These marked photos proved to be of great value to the police and other public officials concerned with the many problems associated with the aftermath of the quake.

Dr. Calio and his group at MSC have been concerned with meeting the challenges of providing a proper interface between the Earth Resources Data and the public sector. He specifically recommended that the primary interaction should be at the State rather than at a lower level because decision-making is usually accomplished by State authorities.

Mr. Beers and Mr. Kimball presented aspects of the ground based management of data and the TRW Earth Resources study. They gave some of the details of the hardware and software problems associated with the management of a large data base.

EARTH RESOURCES SEMINAR

Alan Stevens
Maps and Surveys Branch
Tennessee Valley Authority
Haney Building
Chattanooga, Tennessee

Mr. Alan Stevens of the Maps and Surveys Branch was the moderator for the meeting. Others from TVA attending the seminar were Mr. Roger Betson, Hydrologist, Mr. Al Foster, forester, Dr. Wesley Smith, agriculturist, along with Mr. Don Malone and Mr. Steve Weber. The general position of these potential and existing users of earth resource data was one of conservative optimism. There is caution because new techniques need to be proven to be better, more economical and provide more data than present methods used by the various groups in TVA.

Their organization chart shows top authority residing with their Board of Directors who are political appointees. Their major interests are in navigation, flood control and power generation. The division of Water Control Planning is operating as a service organization but would have a major input on planning flood control dams and/or proving their feasibility.

In representing the position of Navigation and Regional Planning, the moderator stated that Maps and Surveys Branch wants a land use inventory of the valley beginning with two former dates and then adding the current status. Their objective is to identify plans, coordinate efforts and direct actions from an environmental-impact viewpoint. By the end of '72, they want an overview for each sub-region on a 1:250000 base map including sufficient details to classify those areas which will not support urban or industrial development. Also, they want to note functional programs and observe population growth to develop residential and industrial overlays. Mr. Richard Ginn was mentioned as a possible contact for further details.

The 1:240000 aerial photos are their primary imagery. Possibly, 1:60000 or 1:120000 may be of some value for revision or update but the scale promised by ERTS-A is much below these thresholds (The ERTS RBV and MSS imagery scales are about 1:750000). Also the ERTS imagery has a resolution of about 100 feet whereas a resolution of less than 10 feet is desired.

Within the land inventory application there is an emphasis on future recreation site location. In order to meet a list of objections in the next decade several tasks are being undertaken including topographic and land use inventories. Remotely sensed data at a scale less than 1:240000 is of little interest. The primary value of gross pictures is to reduce the number of field trips.

During a question-answering session the need for training photo-interpreters who already have another field of expertise was emphasized. Current plans call for training employees in-house but other alternatives would be considered. Although the Army intelligence methods would provide useful curriculum material, there is a security problem with their training aids. They would be interested in a 3 month training program offered by NASA provided it was cost-effective enough to be able to justify the program to their managers.

EARTH RESOURCE SATELLITES AND DEVELOPING COUNTRIES

Charles Weiss, Science Advisor
International Bank for Reconstruction and Development
1818 H. Street, N. W.
Washington, D. C. 20550

Dr. Charles Weiss discussed the possible applications of earth resources satellites to developing countries.

Needs of developing countries for information are far more acute than the needs of the United States. This fact has two consequences. (1) Information most desired by developing countries is less sophisticated than what the U. S. needs, (2) The problem will be to demonstrate to potential users that earth resources satellites can provide data obtainable in no other way. It will then be necessary to train and equip potential users in techniques of interpretation and analysis.

The World Bank Group was identified as the largest public international agency that makes available capital to meet development needs of developing countries. This group includes (1) The World Bank, which lends money at near commercial rates, (2) The International Development Association, the Bank's "soft loan" affiliate; and, (3) The International Finance Corporation, which lends money to, and invests money in, private enterprises in the developing world.

Bangladesh and the Mekong River Basin illustrate a regional approach to resource development for possible usefulness of satellite data to a developing country. The map of Bangladesh, prepared by the Bank Staff, depicts the best up-to-date knowledge (often 20 years out of date) concerning land use, water use, population density, geology, and other information essential to national planning. Satellite data is essential for sound medium - or long-range planning in developing countries. The Bank is the executing agency for the so-called Pioneer Project program of the United Nations aid program.

In some developing countries the first data presented must be chosen as much for its psychological impact as for its economic value. Special users must be selected to demonstrate the usefulness of new technology to the country's needs.

Dr. Weiss discussed real and urgent political ramifications of earth resources satellites. The international planning process should consider management of sophisticated and rapidly evolving satellite technology and also remain sensitive to political situations.

An idea has been suggested to include an international data bank to obtain and distribute information concerning countries other than the United States and a consortium of the larger and more sophisticated developing countries to hire agencies or companies to design, launch and manage a satellite specifically designed for their needs.

Mr. Norman K. Olson
Geological Survey of South Carolina

"Multi-spectral Photography Applications to Land and Mineral Resources in South Carolina." Ten geologists are participating and two test areas are being "ground-truthed." Mr. Olson feels satellite photos need to be supplemented by aerial photos.

A proposal for ERTS-B is also being formulated by USC Engineering Dean Roger Holmes for state-wide, interdisciplinary problems.

Two meetings with users have been held with State agencies being in the majority.

Mr. Olson hopes the State will support a remote sensing center in Columbia similar to the setup in Iowa - Iowa Remote Sensing Lab
Iowa Geological Survey
16 West Jefferson
Iowa City, Iowa 52240
James V. Taranik, Supv.
(319)-338-1173

Mr. Olson recommended the following reference:

Stafford, D. B. A State of the Art Survey of the Applications of Aerial Remote Sensing to Coastal Engineering, Clemson University, Department of Civil Engineering, May 1972.

He feels his State needs to start with modest, tractable problems to be able to really get the benefits of the ERSP. South Carolina has ten planning districts built up on a county basis.

A regional center concerned with remote sensing technology was viewed favorable --- especially in light of hardware costs and state budget levels for such items. South Carolina is holding a second Governor's Conference on Land Use this summer.

FIELDS within FIELDS within FIELDS

Julium Stulman, President
World Institute Council
777 United Nations Plaza
New York, New York 10017

Mr. Stulman quoted from some of his writings in the series Fields within Fields within Fields which are available from the World Institute. He then suggested a number of ways in which earth resources might be used for economic benefit. He is concerned that the word "exploitation" has such an unfavorable connotation in the public eye because he feels that our resources should be developed and exploited for the well being of mankind. He is enthusiastic about the possibilities of Earth satellite data helping men to locate the resources that may otherwise remain hidden if only Earth-bound exploratory methods continue to be relied upon.

Mr. Stulman has had wide experience in founding and managing a variety of industries.

FUNCTIONS OF THE WATER RESOURCES COUNCIL

Stuart Pyle, Assistant Director
Federal/State Programs
Water Resources Council
2120 L. Street
Washington, D. C. 20037

Mr. Pyle distributed pamphlets describing the Water Resources Council, its formation, and its functions.

He displayed a copy of a report on the Nation's Water Resources and indicated that 20 regions with River Basin Commissions were delineated via this report. The states support a portion of each Commission to which they belong.

The Council's testimony to the Appropriations Committee for FY73 along with a booklet on their policy regarding Water and Land Resources Planning were discussed.

A differentiation was made between the two types of studies that have been done; Type 1 or Framework Studies, and Type 2 or Regional and River Basin Plans.

The latter type of study is a more detailed version of the former type.

There is no central point at present for accumulation and distribution of information obtained in various studies. The strategy of the studies is as follows:

1. Project economic, environmental, demographic factors
2. Determine water and land resource demand
3. Determine water and land resource availability
4. Develop alternative solutions

Mr. Pyle discussed the efforts of the National Programs Assessment Committee. Their objectives are:

1. to obtain a nationally consistent information base
2. develop a manual and computer-oriented program for evaluation and assessment
3. develop a user awareness plan (manifested as information on the adequacy of current resources)

The users were listed as executive offices, congress, WRC, river basin commissions, state agencies. There are no direct ties to industry or education.

THE TENNESSEE STATE PLANNING OFFICE

Tilden Curry, Director
State Planning Office
Niles Schoening, Director
State Planning Division of TSPD
660 Capitol Hill Building
Nashville, Tennessee 37219

The Tennessee State Planning Office was placed under the office of the governor by action of the State legislature. Prior to this legislative action (effective 1972) the Planning Office was a Planning Commission, staffed by citizens, appointed by the governor.

Tilden Curry is Director of the Planning Office. It is subdivided into three divisions: (1) Local Planning; (2) Regional Planning; (3) State Planning. Mr. Schoening is the Director of the State Planning Division. This division concerns itself with: (1) State Development Planning (long term); (2) Budgetary/Fiscal Planning (what and when to invest); (3) Planning coordination.

Tennessee is in the process of subdividing along lines similar to Alabama's "COGS". An emphasis was placed on the fact that Tennessee was to be subdivided according to State Law. No federal influence was sought or desired.

Current practice in Tennessee is to place land use control at the local level. What land use surveys there are, are locally done and of highly variable quality. A bill is now pending in the Tennessee State Legislature which would place land use control under State control.

A general discussion ensued during which it became evident that Mr. Schoening and Mr. Curry were somewhat less than enthusiastic about satellite data on earth resources or earth resource information management systems. They don't want to be told what to do about information management or remote sensing but are reserving the right to be convinced of the appropriateness of its use in Tennessee.

DATA BASE ASPECTS OF AN INFORMATION SYSTEM

Jerry Ulrikson, Director
Environmental Information Office
Oak Ridge National Laboratories
Knoxville, Tennessee

Dr. Ulrikson made several points about data management aspects of the operation at Oak Ridge National Laboratories.

- o Effort at ORNL started about 2 years ago, funded by NSF.
- o ORNL spends about 1.2 million on their Environmental Information System Office.

- o They share data bases. For example EPA has 15 of them. ORNL is connected to this, on-line.
- o As of 2 years ago, there were about 200 environmental information centers .
- o When given a question, they attempt to answer it, rather than referring the user to someone else.
- o Their interactive search program is called ORLOOK. It's slow but it is very flexible.
- o Described the 20 data sets internally accessibly by ORLOOK.
- o Some of the offsite data bases are:
EPA data bases, STORET, etc.
- o Their services are free, but they expect that charges will soon be imposed because costs must be recoverable (this is a political consideration).
- o Their computers are primarily IBM 360/75 and IBM 360/91
- o AEC has a Division of Environmental Affairs and a Division of Regulatory Standards.
- o ORNL's environmental computer programs are available free. (Information Retrieval Programs).

THE RALI PROGRAM

Bruce Hanshaw, Deputy Assistant Director
 Olaf Kays, Information Computer Specialist
 Avery Drake, Geologist
 U. S. Geological Survey
 Washington, D. C. 20500

A meeting was held in the Conference Room of the State Office Building between representatives of the State Government of Alabama and the U. S. Department of Interior. The purpose of the meeting was to discuss RALI, which is an acronym for Resource and Land Information. Those attending the meeting from the U. S. Department of Interior, specifically, the USGS, included Dr. Bruce Hanshaw, Deputy Assistant Director; Dr. Olaf Kays, Information Computer Specialist; and Mr. Avery Drake, Jr., Geologist. Mr. Ed Hudspeth of the Alabama Development Office hosted the meeting.

Dr. Hanshaw stressed the need for a nationally coordinated, decision-making group in regard to many of the national decisions that need to be made. He mentioned specifically the problem areas of electrical energy and land use for which a national use policy is urgently needed. He discussed RALI, which now exists only as a concept. The purpose of RALI is to establish an organization that will pull together existing information on natural resources and land use and share it in a uniform manner with various State and industrial people and agencies.

Dr. Hanshaw stressed the land use aspects of RALI. One plan they have in mind is to have the Air Force place an RB57 in the air

continuously to photomap the entire U. S. on about a three-year time frame. He indicated that many other Federal agencies were interested in establishing an information management program. He specifically mentioned NASA, AEC and the Department of Defense. He felt that NASA and other agencies could contribute very constructively to the program that is envisioned for RALI.

Mr. Olaf Kays expressed concern about the computer aspects of RALI. The country is to be divided into 10 Federal Regional Centers which will be intertied among themselves and with various State systems. Although there will be much commonality among the Federally controlled computer equipment, problems are certainly going to arise when trying to interface the data output of the Federal centers with that of the various State agencies which use different computers and data formats.

Dr. Hanshaw stressed that the State should be the focal point for establishing system operating policy and procedures. He does not care for the idea of a federally centralized information management system which is controlled from the top. When asked if the RALI system will be staffed with professionals who will be eager to serve the prospective users, Dr. Hanshaw replied with a firm "yes". He feels that there must be strong interaction between the potential users and the system, if the RALI information management system is going to work. At this time, he is not sure that the system can accomodate the man on the street. He envisions RALI as a system that interacts with various State agencies, industrial groups, as well as individual scientists and engineers.

Dr. Hanshaw and his associates are now in the process of touring six states, which include California, Texas and Alabama. The purpose of their visit is to see what is needed and to try to accomodate these needs in the conceptual plans for RALI. He and his associates are now distributing a User Requirements Checklist which they hope to use to determine user needs. However, they indicated that this checklist is really not too successful since usually the user does not know what to ask for until he is shown just what the information system can provide. Dr. Hanshaw feels that information should be presented in a neatly understood and attractive fashion and he particularly stressed the use of maps and charts as opposed to tabulated data.

SPACE STATION DATA FLOW

C. D. Jackson
R. E. Gordon
International Business Machines
150 Sparkman Drive
Huntsville, Alabama 35805

The IBM presentation made by Mr. Jackson and Mr. Gordon was a condensation of a technical review for NASA in April 1972. For our purposes the Data Collection and Dissemination System described would be considered as one subsystem of the proposed ERISTAR network.

Mr. Jackson's Talk included these recommendations:

1. Regional Data Centers located in the area of the users,
2. Decentralized Archival and Processing functions to provide manageable units with satisfactory response time,
3. Centralized Data Cataloging and Abstracting Service,
4. Systematic Purging of Data Files over time to reduce storage requirements.

In a round-table question and answer session Mr. Gordon and Mr. Jackson made reference to other items of interest:

1. Ground Truth is necessary to verify results of analysis of MSS data.
2. Department of Defense Technology is being released gradually to advance the state of the art - higher resolution, for example. This may be a mixed blessing since it increases the total data flow.
3. Principal Investigator interaction with the mission management can reduce the data load significantly as unsuitable or usable data is not collected.
4. The experimental platforms used in the ERTS program may cause interference with the MSS system. Thus, there is a possibility that the ground measurements may not be recorded with MSS data.
5. Cataloging other existing sources of Earth Resource Data has not been considered to date.

COSATI

Andrew Aines
Senior Staff Associate
National Science Foundation
1800 G. Street, N. W.
Washington, D. C. 20550

Mr. Aines, Senior Staff Associate, NSF, and a member of the National Committee for Libraries and Information Science, emphasized the role of the Committee on Scientific and Technical Information (COSATI) in his discussion on information management systems. The objectives of COSATI are:

- o Coordinate scientific and technical information programs of Federal agencies
- o Foster development of national systems for information transfer

The organization of COSATI consists of five panels - Information Systems Management, Information Analysis Centers, International Information Activities, Library Programs, and Legal Aspects of Information Systems - and two Task Groups - Chemical Information Systems and Federal Funds for Scientific and Technical Information.

Member agencies of COSATI are the Departments of Agriculture, Commerce Defense, Transportation, Interior and State along with AEC, HUD, HEW, NASA, NSF and the VA. Observers are Office of Science and Technology, Office of Management and Budget, Office of Telecommunications Policy, Office of Emergency Preparedness, Agency for International Development, Arms Control and Disarmament Agency, Environmental Protection Agency, General Services Administration, Government Printing Office, Library of Congress, National Academy of Sciences, Small Business Administration, Smithsonian Institution and U. S. Postal Service.

Some of COSATI's accomplishments include:

- o Policies
 - Page Charges
 - International Relationships
- o Standards and Guidelines
 - Technical Report Format
 - Subject Categories
 - Microfiche Specifications
 - Bibliographic Computer Tapes
- o Studies
 - National Information Systems
 - Scientific and Technical Data Activities
 - Copyright

Mr. Aines cited some of the reasons for COSATI being involved in the information problem.

- o Increase in numbers of information generators and users
- o Increase in volume of scientific and technical information and data
- o Proliferation of scientific fields and specialities, many multi-disciplinary

- o Increase in the number of new mechanized information systems with considerable impact on more conventional systems
- o Soaring costs of information-processing which is now "big-business"
- o Internationalization of major information systems
- o Arrival of new technologies: computers, xerography, micro-photography, long-range communications (including communications satellites)
- o Need for better interagency communication, information-sharing, harmonization of programs, and economy
- o Participation in the budget process, working with each agency and the Office of Management and Budget providing analyses and recommendations
- o Interaction with committees and individuals of Congress concerned with communications program development and information-handling problems in and between both branches
- o Pressures from all sectors in and out of the government to provide leadership and support

Mr. Aines concluded his presentation with some of the long-range and continuing issues that merit attention:

- o Actions to improve communications with such groups as: Congress, Office of Management and Budget, Professional Societies, Educational Groups, National Academies of Science and Engineering and the profit and not-for-profit sectors
- o Review the status and effectiveness of the government information services
- o Probe for quantitative measures to evaluate the efficiency and effectiveness of services
- o Provide leadership in the development of programs seeking to participate in emerging networks for knowledge
- o Active steps to improve the quality of government-produced technical reports and their dissemination
- o Integrate government programs in information science technology to minimize duplication and gaps
- o Encourage participation of scientists and engineers in the development of supportive information systems
- o Encourage better planning, organization, and maintenance of large-scale computerized data banks in science, technology, education and socio-economic fields.

EARTH RESOURCES DATA MANAGEMENT AT MSFC

Robert E. Cummings
Aerospace Specialist
Flight Data Statistics Office
Marshall Space Flight Center, Alabama 35812

The preprocessing of images for computer classification includes normalization and enhancement to remove errors such as shadow effects. The preliminary analysis, which is only a small sample of the data, produces statistics in one or two dimensions. One view used primarily for study purposes is called an isometric plot. The amplitude of the scan is plotted at a skewed angle, thus, boundaries and abnormalities appear as shaded areas. Gray land plots are produced in black and white with various contours developed to assist in data analysis. In preparing boundaries on aerial photos the problem of correcting for roll and yaw error which exist for aircraft may not exist from satellite platforms.

Since supervised classification schemes were presented earlier, Mr. Cummings concentrated on unsupervised classification. Usually a number of categories is specified (from 12 to 64). The program adds categories up to the specified limit and then combines some to best identify the homogeneous areas.

Examples of their work included a wilderness area of Yellowstone Park and a strip of the Purdue data which they classified.

The 3 classification methods used are: (1) sequential statistics, (2) K-mean iteration, and (3) a combination of these two. Although method 1 is fast, startup effects propagate thru the analysis. Since method 2 requires an initial classification and is rather slow to give coverage even after several iterations, method 3 was developed. Method 1 is used to get a good, quick estimate and then method 2 is used to get classification accuracy. Some 2nd generation techniques are being tried inside a boundary once it is closed; however, the need for more work is recognized for this area. The results of the analysis can be put on computer listings or by using Stromberg-Carlson 4020 can be put directly onto 35mm microfilm. The current classifier algorithm on an IBM 7094 takes about 100 lines per minute (depending on the precision on the line). Better than 85% accuracy was obtained under test conditions.

The needs which Mr. Cummings recognizes as most critical are:

- o a systems approach to the total problem of processing users' requests as a function of storage available.
- o data bank entry, update, and inquiry
- o change detection (every 18 days for ERTS).
- o single point anomalies need to be identified.

- o a processing section design team is needed.
- o more preprocessing is needed to remove atmospheric effects.
- o 2nd generation techniques need more development.
- o optical processing techniques need more development
- o Fourier Transform techniques need development
- o control loop optimization is needed with adaptive logic
- o inactive classification should be provided
- o spatial and spectral neighbors need integration
- o there should be a presentation by a color display

THE EARTH RESOURCES TECHNOLOGY SATELLITE

Bruce Bachofer
 Systems Manager for Earth Resources Program
 General Electric Company
 Valley Forge, Pennsylvania

Dr. Bachofer gave a comprehensive, yet somewhat detailed, overview of the ERTS program. Some of the ERTS A/B System features include:

- o A lifetime objective of one year
- o A sun synchronous, circular, near polar orbit of 492 nautical mile. The orbit is sun synchronous so that the Earth will be illuminated for good viewing by the RBV and MSS imagery equipment. The orbit is circular so as to minimize scale and resolution distortion.
- o The attitude control is less than 0.7° for all axes.
- o Repetitive coverage occurs every 18 days.
- o The payload capacity is 600 lbs. with a total spacecraft weight of some 1800 lbs.
- o A 20 minute sensor operation per orbit.
- o Wideband data transmission of 20 MHz in the S-band.
- o On-board data recording.
- o Orbit adjust capability.

The return beam vidicon (RBV) has three spectral bands of 0.48 - 0.575 microns, 0.58 - 0.68 microns and 0.69 - 0.83 microns. A pan-chromatic view would materially improve the RBV imagery resolution but even though some resolution is lost, the choice of 3 bands improves signature information.

The multi-spectral scanner (MSS) employs 4 bands of video (0.5-0.6, 0.6-0.7, 0.8-1.1 microns) and one infrared band of 10.4 to 12.6 microns. Thus the RBV and MSS imagery, in large measure, yield complimentary information.

Ground control points (GCP) represent any feature that is visible in the ERTS image and locatable on a map. The GCP's provide location to map accuracy and precision error measurement. No knowledge of possible error sources is needed when using GCP's.

Dr. Bachofer discussed the salient features of the Ground Data Handling Subsystems, the operations control center and the photo laboratory. The bulk processing requirements includes a through-put performance of 1316 scenes (9212 images) per week and a functional conversion of RBV and MSS video to film and tape. The precision processing requirements include a throughput of 65 scenes per week and several functions including image conversion to 9.5 inch film (1:10⁶ scale).

For further information the reader is referred to the Data Users Handbook for ERTS.

APPENDIX G

GLOSSARIES USED

GLOSSARY I

AM -- Amplitude Modulation

APC -- Auxiliary Processing Center

Band -- bits per second

bpi -- bits per inch

bps -- bits per second

B-W -- black and white

C -- Color

CAC -- Current Awareness Centers

COM -- Computer Output on Microfilm

CONsole system with a computer

COSATI -- Committee on Scientific and Technical Information

CPC -- Central Processing Center

CRT -- Cathode Ray Tube

DARE -- Document Storage and Retrieval System

DCS -- Data Collection System including ground platforms for ERTS

DISC -- District Information Sources Center

DMS --Data Management System

DMS/1108 -- Data Management System implemented on the UNIVAC 1108

DS -- Digital Subsystem

EPA -- Environmental Protection Agency

ERIA -- Earth Resources Information Agency

ERIN -- Earth Resources Information Network

EISO --Environmental Information Systems Office at ORNL

ERIPS -- Earth Resource Image Processing System at MSC

ERISTAR -- Earth Resources Information Storage Transformation Analysis
and Retrieval

EROS -- Earth Resources Observations System

ERSA -- Earth Resources Survey Administration

ERTS -- Earth Resources Technology Satellite

ERTS-A -- The program for the first ERTS

ERTS-1 -- The first flight version of ERTS

ESSA -- Environmental Science Services Administration, USDC

FCS -- Federal Catalog System

FM -- Frequency Modulation

gbps -- **Giga**-bits per second (10^9 bps)

GDHS -- Ground Data Handling System at GSFC for ERTS

GIM -- Generalized Information Management System (a TRW product)

GSFC -- Goddard Space Flight Center

GSS -- Growth Space Station

HDDT -- High Density Digital Tape

HOLDOR III -- The third generation of laser memory systems developed
by Carson Laboratories for US Army Missile Command

IAC -- Information Analysis Centers as defined by COSATI

IIGS -- Initial Image Generation System

ISS -- Initial Space Station

JCP -- Joint Committee Printing Units ($8\frac{1}{2}$ " x 11" equivalents)

JPL -- Jet Propulsion Laboratories

kbps -- Kilo-bits per second (1000 bps)

LARS -- Laboratory for Applications of Remote Sensing at Purdue University

LISC -- Local Information Sources Center

mbps -- Mega-bits per second (10^6 bps)

MESH -- Medicine subject headings produced by the National Library
of Medicine

MICOM -- US Army Missile Command

MIRADS -- Marshall Information Retrieval and Display System at MSFC

MSC -- Manned Space Flight Center

MSFC -- Marshall Space Flight Center

MSS -- Multi-Spectral Scanner (4 channels on ERTS-1)

NASA -- National Aeronautics and Space Administration

NASIS -- NASA Aerospace Safety Information System at Lewis Research
Center where an earth resource data base is being developed

NDPF -- NASA Data Processing Facility

NISC -- National Information Sources Center

NOAA -- National Oceanic and Atmospheric Administration, USDC

NSSDC -- National Space Science Data Center

OCC -- Operation Control Center

ORNL -- Oak Ridge National Laboratory

PI -- Principal Investigator

RALI -- Resource and Land Information Program proposed by the Department
of the Interior

RBV --Return Beacon Vidicon (3 channels on ERTS-1)

RC -- Regional Center

RECON -- NASA/RECON -- REmote CONsole

RISC -- Regional Information Sources Center

RISEM -- Regional Information System for Environmental Management

SC -- State Center

SCSS -- Scene Correcting Subsystem

SEPO -- System Education and Promotion Office

SIOMO -- System Internal Operation Management Office

SISC -- State Information Sources Center

STOR -- Storage, Transformation, Organization, and Retrieval
(the subtasks of processing)

TBM -- Terabit Memory (a product of Ampex with $3 \cdot 10^{12}$ bit capacity
with 36 mbps transfer rate)

TLM -- Telemetry

TRIAD -- Tellurian Resources Inventory and Development

TRKG -- Tracking

TTY -- Teletype (eg. Model 33 on 110 band line)

TV -- Commercial Television

UHD -- Ultrahigh Density Tapes ($2.65 \cdot 10^{10}$ bits per reel of 1402 meters
with 9.6 mbps transfer rate)

UNICON -- Unidensity Coherent Light Recoder (a product of Precision
Instrument with 10^{12} bit capacity with 4 mbps transfer rate)

USA -- United States of America

USDC -- United States Department of Commerce

USDI -- United States Department of the Interior

USGS -- United States Geological Survey

+ - Positive photographs

- - Negative photographs

GLOSSARY II

Apollo Applications Program	ITOS
Angstrom (10^{-8} centimeters)	ITU
Aircraft	ITPR
Atomic Energy Commission	JOC
Advisory Group on Supporting Technology for Operational Meteorological Satellites	JPL
Automatic Picture Transmission Camera System	LARS
Applications Technology Satellite	LaRC
Advanced Vidicon (television) Camera System	LV
Bureau of the Budget	MB
Barbados Oceanographic Meteorological Experiment	MET-ATS
Backscatter Ultraviolet (UV) Spectrometer Sensor	MHZ
Centimeter	MGS
Communications Satellite Corporation	MRIR
Cathode Ray Tube	M/S
Data Collection System	MSC
Department of Agriculture	MSPRB
Department of Commerce	MSPS
Department of Defense	MUSE
Department of Interior	MWS
Department of State	NANO-G
Department of Transportation	NAS
Dry Workshop (Apollo Applications)	NASA
Electron Beam Recorder Image Correction	NAV/TC
Electronic Research Center	NDPF
Earth Resources Survey	NESC
Earth Resources Survey Program Review Committee	NMC
Earth Resources Technology Satellite	NMI
Electronically Scanning Microwave Radiometer Sensor	NSF
Environmental Science Services Administration	OPLE
Federal Communications Commission	OST
Field of View	PCM
Filter Wedge Spectrometer Sensor	PSAC
Global Atmospheric Research Program	RBV
Geodetic Satellite	RDR
Greenwich Mean Time	R&D
Geostationary Operational Environmental Satellite	RTG
Goddard Space Flight Center (NASA, Greenbelt, Maryland)	SATS
High Density Digital Tape Recorder	SCMR
High Resolution Infrared (IR) Radiometer Sensor	SCR
Interdepartmental Committee on Atmospheric Science	SEB
Interdepartmental Committee on Applied Meteorological Research	SECOR
Interdepartmental Committee on Meteorological Services	
International Council of Scientific Unions	SIRS
Image Dissector Camera System	
Image Motion Compensation	
International Telecommunications Satellite	
Infrared	
Infrared Interferometer Spectrometer Sensor	
Interrogation, Recording and Location System	

Improved TIROS Operational (Satellite) System
 International Telecommunications Union
 Infrared Temperature Profile Radiometer sensor
 Joint Organizing Committee (ICSU/WMO)
 Jet Propulsion Laboratory
 Laboratory for Applications of Remote Sensing
 Langley Research Center (NASA, Hampton, Virginia)
 Launch Vehicle
 Millibar (unit of atmospheric pressure)
 Meteorological ("dedicated") Applications Technology Satellite
 Megahertz
 Multi-detector Grating Spectrometer sensor
 Medium Resolution Infrared Radiometer sensor
 Multi-Spectral
 Manned Spacecraft Center (NASA, Houston, Texas)
 Meteorological Satellite Program Review Board
 Multi-Spectral Point Scanner
 Monitor of Ultraviolet (UV) Solar Energy sensor
 Microwave Spectrometer sensor
 Acceleration of gravity constant $\times 10^{-9}$
 National Academy of Sciences
 National Aeronautics and Space Administration
 Navigation/Traffic Control (satellite)
 NASA Data Processing Facility
 National Environmental Satellite Center (ESSA, Suitland, Maryland)
 National Meteorological Center (ESSA, Suitland, Maryland)
 NASA Management Issuance
 National Science Foundation
 Omega Position Location Experiment
 Office of Science and Technology
 (Executive Office of the President)
 Pulse Code Modulation (telemetry system)
 President's Scientific Advisory Committee
 Return Beam Vidicon
 Realtime Data Relay
 Research and Development
 Radioisotope Thermoelectric Generator
 Small Applications Technology Satellites
 Surface Composition Mapping Radiometer sensor
 Selective Chopper Radiometer sensor
 (RCA electronic tube designation)
 Sequential Collation of Range
 (U. S. Army geodetic satellite system)
 Satellite Infrared Spectrometer Sensor

SMS	Synchronous Meteorological Satellite
SNAP	Space Nuclear Auxilliary Power supply
SO65	(Multi-Spectral Camera Experiment)
SPOC	Space craft Oceanography Project
SR	Scanning Radiometer
SR&T	Supporting Research and Technology
SSASC	Space Science and Applications Steering Committee
STP	Standard Temperature and Pressure
SYNCOM	Synchronous - Altitude Communications satellite
THIR	Temperature/Humidity Infrared Radiometer sensor
TIROS	Television and Infrared Observational Satellite
TOS	TIROS Operational (satellite) System
TROMEX	Tropical Meteorological Experiment (no longer planned)
USAF	U. S. Air Force
USCG	U. S. Coast Guard
USCG	U. S. Committee on GARP
USDA	U. S. Department of Agriculture
USDC	U. S. Department of Commerce
USDI	U. S. Department of Interior
USGS	U. S. Geological Service
USN	U. S. Navy
WARC	World Administrative Radio Conference
WEFAX	Weather Facsimile Experiment (data transmission)
WMO	World Meteorological Organization
WS	Wallops Station research center (NASA, Wallops Station, Virginia)
Z	Zulu Time (GMT)

HRFR	High Resolution Film Recorder
Mbps	1000 bits per second
MHz	Mega-Hertz (signal frequency designation)
MSS	Multi-Spectral Scanner
MUX	Multiplexor
NDPF	NASA Data Processing Facility
NM	Nautical Miles
OCC	Operations Control Center
PCM	Pulse-Code Modulation (a signal transmission format)
RBV	Return Beam Vidicon
VTR	Video Tape Recorder

GLOSSARY **III**

AEC.....	Atomic Energy Commission
Agriculture.....	Department of Agriculture
ARS.....	Agricultural Research Service
BDC.....	Bureau of Domestic Commerce
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BM	Bureau of Mines
BOR.....	Bureau of Outdoor Recreation
BPA	Bonneville Power Administration
BR	Bureau of Reclamation
Calif.	California Department of Water Resources
CE	Corps of Engineers
Census	Bureau of the Census
CG	Coast Guard
Commerce	Department of Commerce
Defense	Department of Defense
DOT.....	Department of Transportation
EDS	Environmental Data Service
EPA	Environmental Protection Agency
ERS.....	Economic Research Service
FHWA.....	Federal Highway Administration
FPC	Federal Power Commission
FS	Forest Service
GS	Geological Survey
HEW	Department of Health, Education and Welfare
HUD	Department of Housing and Urban Development
IJC	International Joint Commission
Ind. Agencies	Independent Agencies
Interior.....	Department of the Interior
NCC.....	National Climatic Center
NFEC.....	Naval Facilities Engineering Command
NMFS.....	National Marine Fisheries Service
NOAA.....	National Oceanographic and Atmospheric Adm.
NODC.....	National Oceanographic Data Center
Non-Federal.....	Non-Federal Agencies
NOS.....	National Ocean Survey
NPS	National Park Service
NWS	National Weather Service
N.Y.....	New York Department of Environmental Conservation
OSW	Office of Saline Water
OWRR	Office of Water Resources Research
Penn.....	Pennsylvania Department of Health
PHS	Public Health Service
SCS	Soil Conservation Service
SF&W	Bureau of Sport Fisheries and Wildlife
State	Department of State
TVA	Tennessee Valley Authority
WPO	Water Programs Office
WRC.....	Water Resources Council

IV

[illegible]

[illegible]